DOCUMENT RESUME

ED 064 178	24	SE 014 231

AUTHOR Gregory, John William

TITLE A Study of the Impact of the Verbal Environment in Mathematics Classrooms on Seventh Grade Students' Logical Abilities. Final Report.

INSTITUTION Ohio State Univ., Columbus. Research Foundation.

SPONS AGENCY National Center for Educational Research and Development (DHEW/OE), Washington, D.C.

BUREAU NO BR-2-E-012

PUB DATE Jul 72

GRANT OEG-5-72-0018(509)

NOTE 116p.

EDRS PRICE MF-$0.65 HC-$6.58

DESCRIPTORS Associative Learning; Doctoral Theses; Grade 7; *Instruction; Learning Theories; *Logic; *Research; *Secondary School Mathematics; *Teacher Characteristics; Verbal Communication

ABSTRACT

The major objective of this study was to determine the relationship between the frequency of use of the language of conditional logic by mathematics teachers and students' conditional reasoning ability. Other objectives were to determine the relationship between student mathematical ability and conditional reasoning ability and the effectiveness of quantifying teacher verbal behavior with respect to time for speaking. Twenty teachers of seventh grade mathematics were audio-taped for five classes each. Those ranked as the top five (TWHR) and the lowest five (TWLR) in the frequency of conditional moves were used to identify student subjects for the testing of hypotheses. The students were administered the "Cornell Conditional Reasoning Test" at the beginning and end of the semester. The TWHR students out-performed TWLR students on the total test, on suggestive content items, on negation items, and on the principle "p only if q, not q : not p." Mathematical ability was found to be highly correlated with the three fallacy principles of denying the antecedent, asserting the consequent, and asserting the converse, and with the total test. No interaction of mathematical ability and teacher frequency of conditional moves was found. The length of time for speaking was not closely related to the length of the transcription. Results indicate that future studies of adventitious learning could be useful to educational practices. (Author/JM)

BR 2-E-012
PA 24

NCERD

Final Report

Project No. 2-E-012
Grant No. OEG-5-72-0018(509)

John William Gregory
The Ohio State University Research Foundation
Columbus, Ohio 43212

A STUDY OF THE IMPACT OF THE VERBAL ENVIRONMENT IN MATHEMATICS CLASSROOMS ON SEVENTH GRADE STUDENTS' LOGICAL ABILITIES

July, 1972

U.S. DEPARTMENT of
HEALTH, EDUCATION, and WELFARE

Office of Education
Bureau of Research

SE 014 231

Final Report

Project Number 3369-A1
Grant Number OEG-5-72-0018(509)

A STUDY OF THE IMPACT OF THE VERBAL ENVIRONMENT IN MATHEMATICS CLASSROOMS ON SEVENTH GRADE STUDENTS' LOGICAL ABILITIES

John William Gregory

The Ohio State University

Columbus, Ohio

July 1972

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
Bureau of Research

TABLE OF CONTENTS

LIST OF TABLES

Table		Page

LIST OF FIGURES

THE IMPACT OF THE VERBAL ENVIRONMENT

IN MATHEMATICS CLASSROOMS ON SEVENTH GRADE STUDENTS'

LOGICAL ABILITIES

by

John William Gregory

The Ohio State University, 1972

Dr. Alan R. Osborne, Advisor

ABSTRACT

The study integrated analyses of teacher verbal behavior and psychological and linguistic analyses of the growth and development of children's logical abilities. The major objective was to determine the relationship between the frequency of utilization of the language of conditional logic by mathematics teachers and their seventh grade students onditional reasoning ability. This relationship was sought in an effort to introduce research dealing with incidental learning on the part of students resulting from the incidental instruction component of teacher use of language. The term adventitious learning was used to describe this type of learning.

Two other objectives of the study were: 1) to determine the relationship between student mathematical ability and conditional reasoning ability; and 2) to determine the efficacy of quantifying teacher verbal behavior according to assumptions that the length of time taken to speak is closely related to the length of a corresponding transcription.

Each of the twenty teachers of seventh grade mathematics selected by random procedures from a total population of eighty-four teachers from a large metropolitan school system, had one of their classes audio-taped five times. The <u>Cornell Conditional Reasoning Test</u> was administered to the students enrolled in each of the selected classes of the twenty teachers during the first month of school and again at the end of the first semester.

Three trained analysts determined the teachers' frequency of conditional moves in the five lessons. The teachers were subsequently ranked on the basis of this analysis with the top five (TWHR) and bottom five (TWLR) being used to identify student subjects for the testing of hypotheses. These two teacher groups yielded significant differences ($p < .005$) in frequency of conditional moves per lesson.

Multivariate analysis of covariance (pretest serving as the covariate) was used to determine significant differences ($p < .05$) and to adjust mean scores for computing correlational coefficients. The TWHR students out-performed TWLR students on the total test ($r = .429$), on suggestive content items ($r = .536$) on items involving negation ($r = .519$), and the principle "p only if q, not q : NOT p" ($r = .422$). Mathematical ability was found to be highly correlated with the three fallacy principles of denying the antecedent ($r = .450$), asserting the consequent ($r = .646$), and asserting the converse ($r = .446$) and the total test ($r = .473$). No interaction of mathematical ability and teacher frequency of conditional moves was found.

It was found that the length of time it takes to speak is not closely related to the length of the corresponding transcription.

The results of the study indicate that future studies dealing with adventitious learning can expect to yield evidence of broader implications for educational practices. In addition to the learning of principles of conditional logic, other cognitive developments may be found to be influenced by adventitious learning.

CHAPTER I: INTRODUCTION

The Problem

The ability to reason logically has long been held as a highly desirable human trait. The study reported in the following chapters attempts to discover correlates with this ability. The two variables of concern in this study as possible correlates with student conditional reasoning ability are those of teacher verbal behavior and student mathematical ability.

Introduction and Need for the Study

There have been many studies recently which have described the teaching act in terms of the verbal behavior of teachers. These descriptive studies have been conducted as the necessary preliminary step toward developing a theory of teaching. But efforts to tie the description of cognitive aspects of teacher verbal behavior to cognitive developments of students are notably absent. Several reasons can be given for this void, but if greater knowledge relative to teacher effectiveness is to be gained, then this bridge is necessary.

The utilization of the language of logic has been found to be one operant in the verbal behavior of teachers in all subject areas. Classification systems have been devised to assist in analysis of this component of classroom discourse. However, certain problems have arisen with regard to the overlapping of categories and situations in which categorical definitions were found to be inadequate to ascertain the logical operation being utilized. The suggestion has been made by some researchers to limit analysis to a single criterion to overcome these problems and to obtain what is felt to be a more valuable measure of teacher effectiveness (25:70). This direction is taken by the present study. Only the frequency of utilization of the logical operation of conditional inferring by teachers is considered.

The plausibility of learning occuring as a result of the utilization is discussed at length in Chapter II. Basically it is pointed out that learning can occur in three distinct ways when considered in relation to the intent of the teaching acts. Learning can be intentional or incidental in nature. The difference is dependent upon the student's set to learn to learn. Likewise, teaching can be intentional or incidental. Teaching students square root, for example, could be considered as intentionally taught and intentionally learned. The addition facts might be incidentally learned if the teacher intentionally places the student in a situation which requires the student to become familiar with the addition facts. That is, the teacher's intent is to have the students learn incidentally with respect to the central activity. A third combination is termed "adventitious learning" by the investigator in this study. Adventitious learning refers to incidental learning which is incidentally taught. In this situation neither the teacher nor the student is aware that learning is occuring. The acts of the teacher serve as a model for learning by the students.

This study attempts to lend evidence that this type of learning might occur. Eventually it is hoped that it can be shown that the verbal behavior of the teacher has the effect of shaping student ordinary language into the useful logical reasoning component of critical thinking. But this study is limited to examining the relationship between the frequency of conditional operations in teacher verbal behavior and student conditional reasoning ability. It would seem that knowledge resulting from a study of this nature would be a worthwhile contribution to both the bodies of knowledge from research dealing with classroom verbal behavior analysis and the research domain of psychological and linguistic analyses of the growth and development of children's logical abilities.

Definitions of Terms

1. Category System: a method of classifying discourse relative to the type of cognitive process the utterance is designed to convey.

2. Cognitive Processes: categories of thinking, identified in hierarchical complexity as in Bloom's Taxonomy of Educational Objectives: Cognitive Domain.

3. Frequency of Utilization of the Language of Conditional Logic: the average number of teacher utterances involving conditional logic language.

4. Language of Conditional Logic: statements and questions in which a condition is given and a consequent follows or is to be supplied.

5. Mathematical Ability: the ability to apply mathematical skills and principles as measured by the California Comprehensive Arithmetic Test--Level 3.

6. Ordinary Language: the language used in the ordinary course of events as opposed to artificial language like those of arthimetic and symbolic logic (46:195).

Objectives

1. To describe the frequency of utilization of the language of conditional logic by teachers of seventh grade mathematics.

2. To gain evidence indicating the existence of a positive relationship between:

   a. teacher utilization of the language of conditional logic and student conditional reasoning ability,

   b. mathematical ability and conditional reasoning ability, and

   c. student conditional reasoning ability and a combination of teacher utilization of the language of conditional logic and student mathematical ability.

3. To integrate the research domain of teacher verbal behavior analyses and the body of knowledge emanating from psychological and linguistic analyses of the growth and development of children's logical reasoning ability.

Hypotheses

1. The frequency of utilization of the language of conditional logic by teachers of seventh grade mathematics is not related to their students' conditional reasoning ability.

2. There is no relationship between mathematical ability and conditional reasoning ability.

3. There is no relationship between student conditional reasoning ability and a combination of teacher utilization of the language of conditional logic and student mathematical ability.

Assumptions

1. The five audio-tapings of the classroom discourse for each teacher involved in the study is an adequate measure for significant analysis.

2. Random selecton insures that the effects of variables such as intelligence, motivation, mathematical ability, and teacher personality traits will be randomly distributed across the initial sample of twenty teachers.

3. The instruments chosen will assess the variables for the purposes for which they are being used in this study.

Limitations

1. The presence of an observer and audiotape recorder during the first few taping sessions may influence the utilization of the language of conditional logic by particular teachers being observed.

2. The group being taught may influence the teacher's use of the language of conditional logic.

3. The lesson (content, purpose) may influence the teacher's use of the language of conditional logic.

4. The analysts' competence in using the category system is limited by their understanding of the system and its guidelines.

Delimitations

1. The study will be limited to teachers and their students of seventh grade mathematics from a large metropolitan school system during the academic year 1971-1972.

2. Only the utilization of the language of conditional logic by the teachers in the study will be analyzed.

3. Mathematical ability will be the only subject matter competency measured and correlated with conditional reasoning ability.

Procedures

Prior to the beginning of the 1971-1972 school year, twenty of the total of eighty-four teachers of regular seventh grade mathematics in the Columbus Public School System were randomly selected to serve in the study. These same twenty teachers administered the Cornell Conditional Reasoning Test--Form X to their students enrolled in one of their intact seventh grade mathematics classes selected by the investigator. This September testing date was the same for all students involved in the study.

During a three-week period, all twenty classes were audiotaped five times. The audiotapes were transcribed and the verbal behavior of the teachers was subsequently analyzed according to the frequency of the language of conditional logic used. Ten teachers were selected upon the basis of their assigned rank positions as a result of this analysis. The one class of students for each of these ten teachers served as subjects for the hypotheses testing.

Data on the mathematical ability of the students involved was made available by the school system as measured by the California Comprehensive Arithmetic Test--Level 3, administered in October of the same school year.

Students were assigned to the selected treatments of mathematical ability and teacher frequency of the language of conditional logic utilized.

The second administration of the Cornell Conditional Reasoning Test--Form X to the students on the same day during the final week of the first semester, served as the post-test measure.

A description of the design of the study is as follows:

		Math Ability		
		Above Average	Average	Below Average
Teacher's Rank	High	N = 17	N = 61	N = 36
	Low	N = 11	N = 72	N = 33

Dependent Variable: Post-test

Covariate: Pretest

Data were coded and processed with IBM 360 computer, using programs from the Biomedical (BMD) Computer Program series (18:27): 02D, Correlation with Transgeneration; and using the MANOVA (Ohio State University's version of the Clyde Multivariate Analysis of Variance) computer program. Levels of significance are reported at the .05 level.

CHAPTER II: REVIEW OF THE LITERATURE

This chapter presents a review of three areas of literature. The first is the body of knowledge emanating from psychological and linguistic analyses of the growth and development of children's logical abilities. The second important research base reported is the literature within the domain of analyses of teacher verbal behavior. The third section of this chapter is devoted to a much needed discussion regarding the feasibility of integrating the bodies of knowledge reviewed in the first two sections. Much of the research involving the analysis of teacher verbal behavior assumes an effect on student learning. There has been little discussion regarding how it effects learning and what in particular is altered. The third section of this chapter is directed to the question of how, whereas at least in part, and what is being affected.

CONDITIONAL REASONING ABILITY

Research dealing with conditional reasoning ability can be divided into two areas: (1) investigations of the relationship(s) between conditional reasoning ability and variables such as age, intelligence, socio-economic background, language, etc.; and (2) studies in which the investigator has attempted to promote student logical reasoning ability through formal instruction.

Conditional Reasoning Correlates

Generally studies involving the relationship between conditional reasoning ability and the static variables such as age, IQ, sex, and socio-economic background, have been conducted within the research domain of child growth and development. More recently the studies have taken the approach of contributing to (or discounting) a particular developmental psychology learning theory.

Since knowledge of logic has been considered an intellectual trait, it has often been assumed that a correlate of conditional reasoning ability is intelligence. Studies reported by Winch (70), Ennis & Paulus (21), and Roy (57), found significant positive correlations between intelligence and logical reasoning ability. Others (e.g., White (67) and Glaser (27)) assuming the positive relatedness, have matched or blocked on I.Q. scores or have used I.Q. as a covariate in data analysis.

Age appears to be highly related to logical reasoning ability. However, there is disagreement as to the extent to which younger children can reason logically. Bonser (10), Burt (15), Winch (70), Isaacs (39), Schooley and Hartman (59), Woodcock (71), Miller (49), Hyram (37), Hill (32), and O'Brian and Shapiro (50) all report that subjects of ages six through nine (or younger) can do at least some logical reasoning. These studies have dealt with some of the principles of conditional logic, but have included them in conjunction with other forms of logical reasoning. Therefore, the results have to be considered as generalizations of logical reasoning ability. Description of the extent to which a subject at the age level considered has mastered conditional reasoning is also lacking. Despite these two drawbacks, several of the recent investigators cited above have claimed disproof of the development of logical reasoning as purported by Jean Piaget.

Probably best known for his description of stages of intellectual growth, Piaget (38) maintains that propositional reasoning ability is not developed to any great extent until the age of eleven or twelve, the beginning of the "formal operational" stage. Piaget's "propositional reasoning" goes beyond the twelve principles of conditional logic listed on page 49, in that it includes alternation, disjunction, and conjunction. The following quote testifies to the fact that conditionals constitute a major feature of propositional logic and are central to the ability of operation at the formal operational stage. "Formal operations, therefore, consist essentially of 'implications' (in the narrow sense of the word) and 'contradictions' established between propositions which themselves express classifications, seriations, etc." (53:217). Other features of Piaget's formal operations in contrast with the conditional logic of concern in the investigation in this report are fully discussed by Ennis and Paulus (21), pages V-1 through V-9.

Although Piaget indicates that logical reasoning is not mastered by the age of 11-12 he does not report the degree of mastery possible at this age.

The question of mastery has been investigated by Ennis and Paulus (21). Utilizing an instrument designed to measure an individual's ability to apply twelve basic principles of conditional logic, they found a somewhat linear relation between this ability and age. Although subjects were from grades five, seven, nine, and eleven, they report finding no distinct stages of growth as suggested by Piaget. But "larger jumps [were] found from the fifth to the seventh grade." (21:V-15). This "spurt" of development in conditional reasoning ability could be only partially explained by differences in I.Q. (a nine-point difference favoring the seventh grade subjects). With regard to mastery, they found that for all but four of the principles, roughly half of the seventh grade subjects had exhibited mastery (defined as answering correctly to five out of six items pertaining to each principle or combination).

In addition to differential performance on the principles, their test was designed to measure differential development in terms of three types of item presentation content. The three content components included in their test are:

1. Concrete familiar content--content with which the subject is associated but has no reason to believe to be true or false.
2. Symbolic content--content in which letters replace terms that refer to particular objects in the premises and conclusion.
3. Suggestive content--content which is familiar and whose truth-status is known to the student.

No significant differences were found to exist between the content component effects at any age.

Unlike age and intelligence, the variables of sex and socio-economic status have been found to have little if any relationship with conditional reasoning ability (Burt (15), Miller (49), Hill (32), Ennis and Paulus (21), Howell (34)).

Outside the realm of psychological analyses there have been investigations of the role of linguistics in the child's logical reasoning development. As presented in the writings of Whorf (68), language, conceptual structure, and power to think are intimately related. The research in this area has not sought statistical coefficients to explain the degree of relationship. Instead, as pointed out by Brent and Katz (13), the task has been to find to what extent a person's language determines his ability to make relational discriminations, i.e. to solve problems by responding to the relationships between cues called conditional discriminates (13:2).

Utilizing the narrative discourse technique of "aussage psychologie" (the stimulus is a picture of familiar content to the subject), Brent and Katz (13) report that from ages 6-7 to 11-12, there is a marked increase in "the ability clearly to verbalize causal and temporal relationships. . ."(13:3). Their results indicate consistent progression of the child's understanding of logical connectives which he uses spontaneously. This progression moves from concrete use in speech, to recognizing correct versus incorrect usage in the language of others, to explaining the rule underlying that usage. They comment further that meaningless memorization of rules may actually interfere with the ability to think.

Hunt (36) noted that the use of the term "when" to introduce a conditional decreases sharply from fourth to eighth grade being replaced by the more logically formal term "if" with marked increase in frequency of its utilization in the twelfth.

Several investigators have devised and tested language enrichment projects to show the role of language in structuring logical thought (Brazziel and Terrell (12); Baltimore Public Schools (4); Feldman (23); Bereiter (7); Haywerser, Massari, and Meyer (30; and Blank (9)). Most of the programs have succeeded in promoting I.Q., language ability, and problem solving abilities including those involving conditional discrimination.

Training in Logic

To say that the mathematics curriculum has undergone major revision would be an understatement. One change that is becoming more evident is the emphasis on formalism and the structure of mathematical systems. Many new junior high (and some elementary school) mathematics textbooks have included a chapter on formal logic. Whether or not this move on the part of textbook authors has been to promote non-mathematical logical reasoning capabilities is uncertain, but arguments as to the place of formal logic in the mathematics curriculum have arisen.

Exner (22) arguing for including formal logic feels that it is important for the college-bound student who intends to take higher level mathematics courses. But he discounts its effect on the development of logical reasoning ability by suggesting that formal logic should not be a curriculum component for those not needing as much "proof theory" as one who continues in mathematics (22:395). Hilton (33) speaks directly to the question of non-mathematical reasoning development being facilitated by a unit in formal logic, ". . .I would not accept the argument that the topic (formal logic) justifies itself because it teaches the student to think logically. . ." (33:389). So it appears as if the inclusion of a unit on formal logic, when it is included at all, is for mathematical reasoning purposes. Attempting to instill greater logical thinking in students by including a chapter on formal logic may not be well founded if the following studies are considered.

Utilizing the Watson-Glaser Critical Thinking Appraisal, Williams (69) found that a five-week unit on symbolic logic was not superior to a unit on number systems for improving critical thinking skills of freshmen mathematics students. In a similar study, Roy (57) taught one twelfth grade advanced algebra class a unit on logic and proof. He found no significant differences in ability to determine the validity of arguments or to prove theorems using the principle of mathematical induction between this group and a control group presented a unit on the nature of an axiomatic system. Although he concluded that the study of mathematical logic had little or no effect on the ability of twelfth grade students to determine the validity of arguments, it could be argued, as was found in the Williams study, that the mathematical content had an effect of increasing the control group's ability to the same degree as that of the experimental group.

In the second phase of their study, Ennis and Paulus (21) attempted to determine the age at which student conditional reasoning ability could be enhanced through instruction in conditional logic. Each of the twelve principles found in their test were taught to students in fifth, seventh, ninth, and eleventh grades. The instruction involved forty to fifty minutes a day for fifteen days. They did not find much overall improvement until grade eleven. In grade seven, there were no significant differences on any of the principle or content component post-test scores between groups taught logic and those not taught logic. They present (21; VI-15) several alternate hypotheses for the non-significant findings at the early secondary level for variables not accounted for and which need further investigation. These may be summarized:

1. Other school influences--teacher effectiveness in terms of both content presentation and interaction with students; inherent characteristics of groups due to assignment by other than random procedures; other subject matter course work which requires abstract learning.
2. Influences outside of school--parental and other environmental influences.
3. Maturation that does not depend on contributions from the environment.

In summary, several generalizations can be made of the findings reported in this section. Age and intelligence are the only variables which have been found to have significant correlations with the ability to apply or recognize correct use of the principles of conditional logic. While there is disagreement with regard to the degree of mastery, there seems to be a consensus of opinion that at least by the seventh grade (age 11-12), children exhibit some conditional reasoning ability. It is suggested further (Piaget, Ennis & Paulus) that this age group exhibits the unique quality of greater increase in this ability than at other ages.

Other investigators have found that teaching formal logic to this age group appears to be of no value; that other environmental and scholastic influences appear to be present.

Still others are working under the assumption that the relation between language and logical thought is a strong one. The outside influences referred to by those instructing students in logic may be at least partially explained by improvements in linguistic capabilities of students.

TEACHER VERBAL BEHAVIOR

In tune with the findings reported in the section above, educational researchers desirous of developing a theory of instruction feel that the combination of curricular materials, environmental influences and teacher effectiveness in presentation of materials interact to achieve the intentional aim of teaching: learning by students.

The question of teacher effectiveness has been asked by some educational researchers in terms of pedagogy or didactics. For example, in relation to logical reasoning development, a study by Hannemann (29) sought to find the effects of two methods of instruction on sixth grade pupil reasoning ability. Social studies classes were either taught using the "inquiry method" or the "traditional approach." No significant differences existed after treatment between the logical reasoning abilities of the two treatment groups.

A more recently developed area of research has been involved with isolating one element of the complex task of teaching, namely the verbal interaction between teacher and student, for analysis. The utilization of language by the teacher is considered to be especially important. Aschner puts it this way (1:124):

> The language of teaching is the language of responsible action taken to influence behaviors of those under instruction. The teacher's two fold dealings with language in the classroom cast him in the role of strategist and tactician in the campaign for learning. First he acts with language, using it in the performance of almost all those actions describable as teaching. Secondly, the teacher studies and interprets verbal action; he observes what his pupils say and do under instruction. He does so in order to predict--diagnose and adapt his teaching to the pupils' present state of comprehension and progress in learning, to appraise the quality of their reasoning, and to assess their emotional reactions to the situation of the moment. The teacher's control over his dealings with language thus determines in large measure his success (or failure) to induce the educational results for which we send our children to school.

This quote serves as an introduction to this section of related literature which will report procedures and results of teacher verbal behavior research.

Descriptive Studies of Teacher Verbal Behavior

Studies in the domain of teacher verbal behavior analysis have generally been separated into those dealing with affective characteristics and those dealing with cognitive characteristics. Although it seems more feasible that cognitive aspects of teacher communication skills are related to cognitive developments in their students, this does not rule out the possibility of affective characteristics being involved. However, a study by Measel (48) may serve to discount this possibility. Investigated was the relationship between teacher verbal behavior and levels of thinking (based on Taba's system of Cognitive Tasks) of second grade students as expressed in their verbal behavior. Using the affective characteristic discriminates as set forth in Flanders' System of Classroom Interaction Analysis, teachers were determined to be either Direct or Indirect and grouped accordingly. The results showed that when these two groups were compared, there was no significant difference in pupil utilization of the higher levels of thinking. Of greater importance, the results showed that pupils tended to respond at higher levels of thinking when teachers functioned at those levels.

Gallagher, Aschner, and Jenne (26) report similar results of their analysis of the cognitive verbal behaviors of teachers and students. Using Guilford's Structure of the Intellect model, they report increased divergent production by gifted high school students in English, science, and social studies classrooms resulting from a slight increase in use of divergent questions by teachers.

Wright and Proctor (72), Smith and Meux (61), Bellack (6), Gallagher, Aschner, and Jenne (26) have all reported that conditional inferring constitutes a portion of teacher verbal behavior regardless of subject matter content. The findings of Smith and Meux (61) have been the only ones found which exhibit actual frequency of teacher utilization of this specialized language of logic. And they appear to support the contention that teachers of mathematics utilize conditional inferring more than teachers of other subjects. This investigation suggests greater homogeneity of results will be achieved if observation of the language of logic is limited to one subject area only.

Taking this direction, Fey (24) analyzed the verbal communication in seventh grade mathematics classes in terms of source, pedagocial moves (four categories), duration, content (21 categories), mathematical activity (14 categories), and logical process (11 categorees). Fey found that the structure and content of mathematics exerts a definite influence on the pattern of discourse. Comparing his results with those of Smith and Meux (61) and Bellack (6), the patterns of verbal activity in mathematics classes differs in several ways from those characteristic of other subject matter classrooms. The differences appear to arise from the finding that each utterance about mathematics serves a mathematical purpose by further development, examination, or application of mathematical system.

It is interesting to note that Fey encountered certain major problems in coding logical processes. One difficulty arose from certain ambiguities in his operational category definitions of logical process. For this reason, the findings of his study do not include teacher utilization of the language of conditional logic. Further discussion as to the nature of this problem is included in Chapter III.

Of the few studies dealing with cognitive verbal behavior of teachers, fewer have reported frequency of teacher utilization of the language of conditional logic. Therefore, the findings reported thus far must be accepted as tentative.

These descriptive studies have shown that part of the language of teachers involves conditional logic items. As Smith and Meux (61) found, the most frequent utilization of this type of language occurs in mathematics classrooms. Further, it was found (Fey (24)) that a distinct pattern of classroom discourse is apparent in mathematics classes and students tend to follow the language patterns established by their teachers (Measel (48); Gallagher, Aschner, and Jenne (26)).

It would now be appropriate to have a section entitled "Teacher Verbal Behavior--Experimental Studies." However, all experimental studies examined in this area either deal with the affective domain or are ones in which the investigator had selected a particular verbal behavior characteristic of teacher effectiveness and sought to modify teacher behavior to include or emphasize it, assuming that a positive effect on student learning would result. More aptly put, ". . .there is yet to be constructed a sturdy bridge between the science of learning and the actual management of instructional dialogues." (Jahnke (40:187)).

SHAPING STUDENT ORDINARY LANGUAGE

Any engineer faced with the task of constructing a bridge must first deal with the question of plausibility. This section reviews literature which makes credible any attempt to integrate the research domains of analysis of teacher verbal behavior and psychological and linguistic analysis of the growth and development of children's logical abilities.

Language and Logic

It is rarely necessary to define language since it is as natural to man as is swallowing and breathing. But language will serve as the gauntry in the bridge construction which is to follow. Therefore, it is important to start with a formal definition. The definition extended by Sapir (58:8) will serve nicely: "Language is a purely human and non-instinctive method of communicating ideas, emotions, and desires by means of a system of voluntarily produced symbols." This definition will find much agreement from the reader but there is one point worthy of note. "Non-instinctive method" means language, unlike swallowing and breathing, must be learned. In the same article presenting the definition, Sapir explains that language is an acquired "cultural" function. He points out that if the society were to be eliminated, there is still reason to believe that man would learn to breathe. "But it is just as certain that he will never learn to talk, that is, to communicate ideas according to the traditional system of a particular society." (58:4). Furthermore, speech varies "without society assignable limit" as do "the religions, the beliefs, the customs, and the arts of different peoples." (58:4).

Explaining the differences in languages of different peoples has been the concern of Benjamin Whorf. He and others have found that not only is language a cultural function but language shapes man's senses and thoughts:

> It was found that the background linguistic system (in other words, the grammar) of each language is not merely a reproducing instrument for voicing ideas but rather is itself the shaper of ideas, the program and guide for the individual's mental activity, for his analysis of impressions, for his synthesis of his mental stock in trade.
> (68:62)

The findings of Brazziel and Terrell (12), Bereiter (7) and others cited above, that language enrichment projects have promoted logical thought can now be seen in a clearer light. As the child's ordinary language is shaped to conform to a more mature language of his culture, his logical thought processes are being developed as well. Suppes (63) attributes the findings of the study by Hill (32) cited above, that young children can do some logical reasoning to the relationship existing between a child's ordinary language and his ability to reason.

> To avoid any possible confusion it should be borne in mind that it is not claimed that this study shows that young children are able explicitly to state formal principles of inference. What is claimed is that their grasp of the structure of ordinary language is sufficiently deep for them to be able to make use of standard principles of inference with considerable accuracy. (63:42)

Given this relationship between an individual's language and his logical reasoning abilities, the next step is to discuss ways in which these attributes are learned.

Intentional and Incidental Learning

Generally learning is discussed on only two levels--intentional or incidental. Intentional learning is learning which occurs with explicit instruction or desire to learn. It refers to learning which an individual consciously attempts to learn. Incidental learning is any learning which occurs without explicit instruction or conscious desire to learn (47:369).

Intentional learning is usually the type under consideration in discussion of the classroom. It is usually transmitted in explicit terms from the teacher to the student, either orally or in writing. The classical incidental learning experiment in psychology exposes the subject to stimulation under conditions which "seem" to exclude motivation to learn and then by testing, determines whether or not learning has occurred. The word "seem" is used considering findings of some studies (cf., Jenkins (41), Postman & Senders (54)) that covert sets, not necessarily reportable by the subjects, may be operating to produce learning.

Several studies of this type (Shellow (60); Jenkins (41); Biel and Force (8); Postman and Senders (54); Tolman (64); McGeoch (46); Bahrick (3); Brown (14); Kausler, Trapp, and Brewer (43); Kausler and Trapp (42); Hetherington and Banta (31); Baumeister (5); and Phye (52)) have shown clear evidence of incidental learning. Overt verbalization by subjects was not found to be a factor influencing this type of learning (Brown (14)). The attention of educators and educational researchers in several different subject matter fields has been drawn to incidental learning. In reading research, or prose learning research, the terms relevant and irrelevant learning are used interchangeably with intentional and incidental learning, respectively. The concern has generally been the role of questions in learning prose material. Both question pacing (insertion of questions after specified amounts of prose material) and question frequency have been found to affect both relevant (intent of the written material) and irrelevant (incidental to the main intent of the material) learning (cf. Koran and Koran (44), Boyd, (11), Quellmalz (55)).

On at least three different occasions within the last fifty years the role of incidental learning in arithmetic instruction has been the concern of mathematics educators (51). Here, the two teaching approaches have been termed "formal instruction" and "incidental learning." Formal instruction refers to systematic instruction via lecture and drill techniques. Incidental learning of number facts was to result from student participation in projects and activities. The idea has been that children will learn as much arithmetic as they need in order to complete an activity unit.

The "core-curriculum" movement of the late forties and early fifties is one example of the occurrence of great debate among mathematics educators with regard to incidental learning. Current mathematics curricula exhibit the decline of interest in incidental learning of mathematics.

It is interesting to note that in all of the above references concerning incidental learning, it has been intentionally induced; that is, consciously directed by those in the role of instructor (the psychologist, the reading specialist, the mathematics educator). Might there not also be a third level of learning which would involve "incidental instruction" (that is, instruction occurring without the intent of the instructor) and incidental learning on the part of the subject-student?

A Learning Triad

It was stated above that in most literature, only two types of learning are discussed. In a book entitled The Silent Language, Edward Hall (28) posits that there are three levels of human behavior. He discovered this tripartite theory through observation of the ways in which Americans talk about and handle time. Formal time refers to the everyday, well-known concept of time by which man works and functions. Informal time involves rather imprecise, situational uses like "in awhile," "just a minute," and "later." Technical time is seen in terms of measurement; the type utilized by the scientist and technician.

Extending this discovery to include many behaviors of mankind, Hall discusses three types of learning. Technical learning is that type of learning which has already been referred to as intentional learning. It involves explicit direction and instruction to learn. Formal learning does not refer to the usual conception of formal learning, that is, intentional learning. Instead, it refers to a special type of incidental learning in which instruction is conveyed through precept and admonition. Hall writes: "The adult mentor molds the young according to patterns he himself has never questioned. . . . Formal patterns are almost always learned when a mistake is made and someone corrects it." (28:69-70). The instructor consciously attempts to shape the child's understanding to conform to patterns and understandings implicit in his culture.

Informal learning, as defined by Hall, provides credence to discussion of the third type of learning referred to above as "incidentally taught" and "incidentally learned." The principle vehicle of instruction which ellicits informal learning is a model used for imitation. Hall writes: "Whole clusters of related activities are learned at a time, in many cases without the knowledge that they are being learned at all or that there are patterns or rules governing them." (28:70). Note that the reference to learning without the knowledge that they are being learned implies nescience on the part of both instructor and learner. The types of behavior which are passed on in this way are numerous and varied. "Entire systems of behavior made up of hundreds of thousands of details are passed from generation to generation, and nobody can give the rules for what is happening. Only when these rules are broken do we realize they exist." (28:71). That this quote is true, consider cultural rules at work regarding social amenities. Very few people can state the rule for "first naming." But upon reaching adulthood, most persons react in the pattern set by their culture. If not, then there is a sense of incorrectness and uneasyness accompanying the situation which follows. Hall gives several other examples: "Everyone has seen small boys mimic their father's walk or imitate a television hero or, at worst, mimic some unsavory character who hangs out at the corner drugstore." (28:71).

Many acts which contradict cultural rules which are passed on by informal learning are sometimes referred to as "unspeakable." The discussion thus far indicates that the rules themselves are more often than not unspeakable in that they cannot be stated explicitly.

Teacher Verbal Behavior, Logical Reasoning and the Learning Triad

The bridge framework used in this study is near completion. All that is needed is to tie in teacher verbal behavior and student reasoning abilities to this more general framework. The discussion will now attempt to show how teacher verbal behavior has been used to instruct children in logic at all three levels of Hall's learning triad. The labels for these types of learning will be changed to coincide with the terms most frequently used in educational circles. Intentional learning will be used to convey Hall's concept of technical learning; his "formal learning" now becomes "incidental learning"; and a new label, "adventitious learning," will be discussed in line with Hall's "informal learning." Parenthetically speaking, the author dislikes having to introduce new jargon into the picture. It is necessitated by a desire to clarify the differences between the two types of incidental learning under discussion.

The language of teaching has already been referred to as "the language of responsible action taken to influence behavior of those under instruction." This will be true for both intentional and incidental learning but will not necessarily be true for adventitious learning.

The language of instruction in intentional learning includes stating of objectives, rules, and directives explicitly. In teaching the principles of logic as a separate content unit, as was the case in the studies of Ennis and Paulus (21) and others cited above, intentional learning was the goal. The findings of these studies indicate that conditional reasoning ability, at least for younger children, is not significantly enhanced by intentional learning.

One finding of the study by Hill (32), although not specifically designed to teach logical reasoning, serves as evidence of incidental learning of the application of principles of conditional logic. She found that a reinforced group which was told the correct answer after each response on an orally administered test of logical reasoning, scored significantly higher than a non-reinforced group. She writes: ". . . the children who are told the correct response can be said to have learned the logical principle involved and applied it to later items." (32:77). Note the similarity to elements in Hall's definition that patterns are learned incidentally "when a mistake is made and someone corrects it."

Aylesworth and Reagan (2), in their text Teaching for Thinking, suggest this teaching strategy as a means to helping students develop the habit of critical thinking (of which the ability to apply principles of logic is an integral part).

> If we are to encourage learners to develop skills in critical thinking, part of our task is to aid them in identifying and avoiding mistakes in reasoning. . . . This does not mean that we need more courses in logic, but that logic could and should be taught as a part of other subject matter and recognized as a crucial part of the critical-thinking process. (2:83)

They are saying that logic can be learned incidentally if teachers make conscious efforts to correct fallacious arguments and invalid conclusions of students.

Exner (22), cited earlier as a proponent of teaching formal logic to advanced mathematics students, concedes that logic may be taught by alternate strategies. He writes:

> It is quite possible to develop logic informally and use it to deal with certain formal aspects of mathematics. By informally, I mean here that one doesn't seek a minimum axiomatic basis from which the theorems of logic will follow rigorously, but rather one accepts a much wider base, guided by the applications one wants to make and by the linguistic experience of the children. (22:394)

The use of the term "informal" can be seen to coincide with the concept of incidental learning. The teacher verbal behavior involving explanations, questions and other logical functions (or "logical operations," to use B. O. Smith's description) instills learning logical principles along with the development of the mathematics lesson.

Exner also refers to the second type of incidental learning discussed earlier and classified as "adventitious learning" by the writer. He sees linguistic experience of the children as a determining factor in the acquisition of logical reasoning ability via this learning type.

Adventitious learning is being used to classify this second type of incidental learning. As stated before, this learning type is characterized by nescience on the part of both instructors and students.

According to the dictionary, "adventitious" is defined as: "added extrinsically; not essentially inherent; acquired, accidental, or casual." Therefore, this is just another way of saying incidental but emphasis is placed upon acquisition by accident. That is, the teacher does not plan to have the material which is learned in an adventitious manner to be learned either intentionally or incidentally (as defined above). Whereas the verbal behavior of the teacher which characterizes strategies to induce the other types of learning, all verbal behavior of the teacher may be considered to be related to adventitious learning. The type of material learned in this manner has already been discussed in general with regard to Hall's "informal learning." Argument that logic can be learned adventitiously draws upon Hall's comments that patterns and rules are learned from models. The model takes the form of the verbal behavior of the teacher.

Findings of studies involving the relationship between linguistics and logical thought have already been cited (cf. Sapir (58), Whorf (68)). Smith (62) describes different teacher roles within the frame of thinking. The teacher is player, coach, and often referee. The role of coach and referee fit the role as discussed under the heading incidental learning. But in all three roles, the teacher's utilization of language can serve as the model which shapes student ordinary language (to use Suppes' term) to conform to the formal language needed to reason logically. Smith (62:228) writes:

> Consider the case of a child learning his mother tongue. As he does so, the child's sentence structure will conform to that of the adult's. The child is not aware of such things as linguistic rules. In the same way, the child's reasoning may be said to conform to the rules of logic. His sentences may express valid arguments. This is rarely the case at an early age, but as the child progresses through the elementary school, he begins, though unconsciously and irregularly, to take on the forms of valid reasoning. In conforming to the rules, the child's reasoning is valid though the idea never occurs to him that he should reason validly. He cannot verbalize the rules of thinking. Hence, his reasoning has not reached the threshold of conscious control. Now in cases of this sort we can say that the extent to which rules are satisfied at all, they are satisfied only by unconsicous accommodation of behavior.

There is only one thing with which this author can find fault in this quote. Smith has tried to draw an analogy between learning of the "mother tongue" and learning rules of logic. This author purports that the two are intimately related, at a much higher level than that of analogy.

This proposition also gains s ıpport from the findings of Gallagher, Aschner, and Jenne (26), and Measel (48) that students used the verbal behavior of the teacher as a model for their own language utilization. Further, the model and resultant "mimicry" involved language of logic in terms of higher level thinking processes.

Much more can be said about this type of learning termed "adventitious learning" with regard to patterns or rules other than those of logic. But the purpose of this study is to determine if there is a relationship existing between teacher utilization of the language of logic and student logical reasoning ability.

SUMMARY

The review of the literature has indicated three possible ways of constructing a bridge between descriptive analyses of teacher verbal behavior and student logical reasoning ability. They are consideration of intentional, incidental and adventitious learning. The latter two methods, in view of research cited, seem to hold greater promise than the first. To the knowledge of this author, neither of these two directions have been investigated. But instruments have been developed to assist in the description of teacher utilization of the language of logic. Hence, it would seem appropriate to start with an investigation of adventitious learning. At least an investigation should be conducted to determine if the teacher's utilization of the language of logic as a possible operant or stimulus for adventitious learning is related to student ability to apply the principles of logic. In addition, it seems particularly appropriate to investigate the relationship between teacher utilization of the language of conditional logic and seventh grade student conditional reasoning ability for two reasons:

1. Conditional reasoning is central to ability in other forms of deductive reasoning (20).
2. The literature reports unique features of the ability to reason with respect to this type of logic at this age level.

Further refinement is also indicated by the literature for a study of this nature. It was reported that mathematics content and, hence,mathematical ability may have been at least partially responsible for non-significantdifferences between groups after logic was intentionally taught. Also there appears to be a distinct pattern of discourse evident in the mathematics classroom with regard to logical and other cognitive operations.

CHAPTER III: METHODOLOGY

Introduction

The central concern of this study was to determine to what extent the frequency of utilization of conditional moves by teachers of seventh grade mathematics and student mathematical ability are related to student conditional reasoning ability. This chapter presents discussion of the five basic procedural phases which led to the results reported in Chapter IV. These procedures took the form of the following phases:

Phase I: A. Selection of twenty teachers of seventh grade mathematics and one of their seventh grade mathematics classes.

B. Administration of the pretest and test of mathematical ability to all students enrolled in the selected classes.

Phase II: A. Audiotape five lessons for each of the twenty selected classes.

B. Transcription of the one hundred audiotapes.

Phase III: A. Analysis of the tapescripts.

B. Training of tapescript analysts.

Phase IV: A. Administration of the post-test to all students enrolled in the twenty selected classes.

B. Administration of a critical thinking test to the teachers involved.

Phase V: A. Selection of population for hypotheses testing.

B. Data analysis.

PHASE I

Since the variable of teacher verbal behavior was to be selected rather than induced, a sample of twenty teachers was randomly selected from a frame of eighty-four teachers of regular seventh grade mathematics employed by a large metropolitan school system. The term "regular" refers to the type of assignment procedures used by the schools to assign students to seventh grade mathematics classes. Based on test scores in areas of reading ability, mathematical ability, intelligence and recommendations of sixth grade teachers, the students were assigned to honors, regular, or modified sections by school officials. Only those classes considered to be "regular" were used in this study with the intention of gaining greater homogeneity of variance on criterion measures for contrasts between groups.

The random sample consisted of nine men and eleven women teachers. The ADC percentages for the schools involved, which appear in Table 18 in Appendix B, yield evidence that fourteen of the twenty are below the average 12 percent of the entire school system.

Additional information regarding the teachers is provided in Table 19. Given are the teachers' scores on the Watson-Glaser Critical Thinking Appraisal and the corresponding percentile ranks based on the scores of all masters candidates at The Ohio State University for the period 1965 to 1970. Four teachers scored in the bottom third, five in the middle third, and eleven in the top third.

One class of each teacher was chosen upon the basis of its meeting time to provide ease in scheduling of taping sessions. On one day during the first month of school, the four hundred fifty-five students enrolled in one of the twenty selected classes were administered the Cornell Conditional Reasoning Test--Form X (19). This test which served as the pretest for this study was designed to measure the ability of students to apply twelve basic principles of conditional logic. Three different content types of items (concrete familiar, symbolic, and suggestive) are used for each principle. These have been described earlier (page 11). A description of the test appears in Appendix A.

As part of the regular testing program of the city school system, the California Comprehensive Arithmetic Test--Level 3 (16) was administered to all seventh grade students on one day during the second month of school. The scores achieved by the students enrolled in the twenty classes on this test were used to determine mathematical abilities. This test is also described in Appendix A.

PHASE II

Audio-tapes of five lessons of each of the twenty teachers selected in Phase I were obtained during a three-week period during the month of October. The lessons were those presented to the one selected class of each teacher. The five audio-tapes served as the basis of a representative sample of the teacher's verbal behavior.

Each teacher had agreed to allow an observer to enter the classroom to audio-tape the lesson realizing only that the investigator would be looking for "certain linguistic patterns." They were contacted prior to each audiotaping session on a day-to-day basis to assure the observer that a lesson would be presented. Scheduling of tests, assemblies, etc. were not changed to accommodate the taping sessions.

Taping during the early portion of the year had the effect of yielding greater homogeneity of the mathematical content of the lessons taped. For the most part, a chapter covering prime factorization, from the same textbook, served as the basis for the discourse in the classroom lessons which were taped.

The five tapings were scheduled as close together as scheduling would allow in an attempt to limit any possible effects of an observer being present in the room.

In addition to attending the microphone and tape recorder, the observer made detailed notes of all writing done at the chalk board. These notes were used to assist in transcription of the tapes.

The transcriptions were typed according to the following stipulations:

1. No more than sixty spaces of type appeared on any one line.
2. All "group audible" teacher verbal behavior was transcribed.
3. No abbreviations were used. (Number words were used instead of symbols.)

The utilization of only sixty spaces of type aided analysis of teacher verbal behavior, as explained in Phase III. Group audible teacher verbal behavior refers to utterances of the teacher which are of such volume that the entire class would hear them. This verbal behavior is not necessarily group directed. For example, if the teacher was reprimanding a student during the presentation of the lesson, then the class usually became silent and was able to hear what the teacher was saying. However, when the teacher had given the assignment and was talking to an individual student at the student's desk, generally the rest of the students were not able to hear what was being said. Verbal behavior of the latter type was not transcribed since the concern of the study involved the impact of the teacher's verbal behavior on the entire class.

PHASE III

Analyses of teacher verbal behavior in past studies have used category systems in which the categories are all encompassing and mutually disjoint. There were two reasons for not following this global pictorialization procedure. First, if teachers do shape the ordinary language of students in ways described in Chapter II, one component of teacher verbal behavior which could be related to student conditional reasoning ability is the frequency of utilization of the language of conditional logic. Second, if more dependable and meaningful information about teacher behavior correlates is to be gained, then analyses taking a less global view of teaching are needed. Gage (25) refers to this idea as "microcriteria of effectiveness."

> Rather than seek criteria for the overall effectiveness of teachers in the many, varied facets of their roles, we may have better success with criteria of effectiveness in small, specifically designed aspects of the role. Many scientific problems eventually have been solved by being analyzed into smaller problems whose variables were less complex (25:120).

Research of this nature is analogous to the investigations by laboratory scientists who contribute to the building of broader scientific theories by making discoveries in which the concern is minuscule.

Therefore, each lesson tapescript was analyzed utilizing only one category of the Smith and Meux (61) classification system. Their system was designed to analyze teacher questions according to "logical operations." Logical operations refer to ". . .the forms which verbal behavior takes as the teacher shapes the subject matter in the course of instruction." (61:3). One other modification of their system utilized in this study involved extending the category of "conditional inferring" from questions only to include statements.

Before a category system can be used, a unit of discourse must be determined. Although the Smith-Meux Classification System was being used, it was decided not to use their unit of discourse, the "episode." Their utilization of the "episode," defined as ". . .the one or more exchanges which comprise a completed verbal transaction between two or more speakers," (61:14) led to unreliability in judging of their tapescripts. Two types of difficulties arose. One type was the overlapping of categories within one episode. The second type of difficulty was the fact that for some episodes, ". . .neither the whole entry nor any significant part of the entry seems to satisfy the criteria of any category." (61:46). For these reasons, another unit of discourse had to be selected.

In one of the very few studies in which cognitive aspects of mathematics teacher verbal behavior is analyzed, Fey (24) used a unit of discourse originally defined by Bellack (6) called a "pedagogical move." As Fey points out:

> The pedagogical move used by Bellack is an uninterrupted utterance or partial utterance of a single speaker which serves the pedagogical purpose of structuring the discourse, soliciting information or action, responding to a solicitation, or reacting to a prior move.(24:17).

Fey was able to further classify moves according to logical process. Although, as noted before, his category system did not enable him to classify "conditional inferring," the problem did not arise from the use of pedagogical moves. Thus, the move was adopted as the unit of discourse for analysis.

The particular problems Fey encountered with the category of "conditional inferring" had to be considered if they were not to be repeated. Although these problems may have been a result of utilizing fifty categories, a closer look is deemed necessary. He reports that the basic problem arose in distinguishing between "fact statements" and "conditional inferring." He states that frequently "soliciting moves that have the appearance of hypothesizing are actually simple requests for statements of fact." (24:34). To account for this,

> . . .regardless of the occurrence of an "if p then - " form, Inf (conditional inferring) was coded only when several appropriate conclusions were possible, or when the given or solicited conclusion was a fact not previously known to the class. (24:34)

Although not reported, further problems must have arisen with this decision for he writes, "The ambiguities. . .involving fact stating and conditional inferring. . .could not be resolved by satisfactory operational category definitions." (24:66).

It was felt that the problem Fey encountered would not appear in this study since only one category was being used and the "if p, then - " form of teacher utterances was considered to be extremely important regardless of the class' knowledge of the conclusion.

In addition to analyzing tapescripts according to conditional moves, they were coded in terms of duration following procedures used by Fey (24). Fey defined the duration of an utterance as the number of half-lines of typewritten copy covered by the transcription of that move. Using five inches of elite type (60 spaces) as the equivalent of one line, "No move was coded as less than one half-line. Partial lines beyond the first were counted if they covered more than half of the next unit." (24:19). His choice of this method assumed that ". . . length of time required to speak is closely related to the length of the corresponding transcription." (24:19).

During a seven-hour training session, ten randomly selected tapescripts were analyzed by three analysts for each of the procedures outlined above. The remaining ninety tapescripts were randomly assigned such that each one was analyzed by two analysts. Reliability of analyst ratings was determined as specified by Lucas (45:80) using intercorrelation procedures. The results of the calculations are shown in Table 1 below.

Table 1. Intercorrelations for Analysts[a]

Analyst	A	B	C
A	---	.96	.93
B	.94	---	.97
C	.96	.97	---

The values below the diagonal are correlation coefficients based on the number of half-line totals per transcript for conditional moves. The values above the diagonal are those for the total frequency of conditional moves per transcript rated by that pair of analysts.

[a] All coefficients significant (p .05).

PHASE IV

During the last week prior to the close of the first semester, the Cornell Conditional Reasoning Test--Form X was readministered to all twenty classes to serve as the post-test measure.

Being unrelated to the major concern of this study, but important to future studies which might attempt to predict the utilization of conditional moves by teachers, the Watson-Glaser Test of Critical Thinking--Form Y (66) was administered to eighteen of the twenty teachers. Two declined to respond to the test. Correlation coefficients were computed to determine the relationship between the Watson-

Glaser total test score and average frequency of conditional moves per lesson, average frequency of conditional half-line per lesson and average ratio of conditional half-lines to total half-lines per lesson. These are presented in Table 3. Raw scores and percentiles are to be found in Appendix B.

PHASE V

The students in the classes of the ten teachers were selected to serve as subjects for hypothesis testing purposes. The selection involved ranking all twenty teachers in three ways:

Method 1: Average frequency of conditional moves per lesson,

Method 2: Average frequency of conditional half-lines per lesson.

Method 3: Average ratio of conditional half-lines to total half-lines per lesson.

These were felt to be the three most appropriate measures of teacher utilization of the language of conditional logic. The frequency of conditional half-lines can be interpreted as a measure of time that patterns of this language type are used. The ratio of the condition half-lines to total half-lines yields a measure of the relative time spent on this type of move. It was decided to use the average frequency of conditional moves per lesson in determining the ten teachers and the student subjects for hypotheses testing for three reasons.

The first reason involved discarding the assumption that the time it takes to speak is equivalent to the length of the corresponding transcription. It was found that the length of time it takes to speak differs to a great extent from teacher to teacher, but the length of transcription remains rather constant.

For each of the twenty teachers, one segment of an audio-taped lesson was randomly selected and timed with a stop watch. The segment was timed until at least five minutes of the teacher's verbal behavior was obtained. The length of the corresponding transcription was measured in terms of half-lines. Table 2 presents the data obtained for each of the twenty teachers.

Table 2. Length of Time Taken to Speak and Length of Corresponding Transcription for the Twenty Teachers[a]

Teacher	Half-line total	Time (seconds)	Half-lines per second
1	187	308	.60
2	225	315	.71
3	208	304	.68
4	184	314.5	.58
5	176	313	.56
6	178	306	.58
7	201	301	.67
8	181	312	.58
9	116	311.5	.37
10	231	354.5	.65
11	209	305	.68
12	225	302	.75
13	212	307	.69
14	175	308	.57
15	182	325	.56
16	152	308	.49
17	232	314	.74
18	221	306	.72
19	181	304.5	.59
20	187	324	.58

[a] r_{xy} = .17 for x = half-line total, y = seconds

The number of half-lines per second varies in range from .39 to .75 for the twenty teachers. The correlation coefficient .17 expresses the relationship between the seconds taken to utter the number of half-lines corresponding to that utterance. This clearly indicates the lack of equivalence between the two measures.

A second finding related to procedural decisions regarded the differences in rank position resulting from the three methods of ranking. Based on the three methods (rankings presented in Appendix B) the correlation coefficients presented in Table 3 indicate that these differences are slight. In future studies only the frequency of move need be considered, thus facilitating the task of analysis. The coefficients relating the Watson-Glaser scores are presented in Table 3 also.

Table 3. Intercorrelations for the Three Methods of Teacher Rank[a]

Method	1	2	3	W-G
1	--	.86	.62	-.10
2	.92	---	.82	-.04
3	.77	.93	---	-.23

[a]The values above the diagonal are correlation coefficients based on the ranks of all twenty teachers. Below the diagonal, coefficients are based on the ranks of the ten teachers subsequently selected.

The feeling that the frequent repetition of a linguistic pattern and not the duration or percentage of classroom discourse of this pattern, has greater impact on the shaping of student ordinary language serves as a third reason for selection based on this method of ranking.

Based upon the rank positions assigned with regard to the teacher's average frequency of conditional moves per lesson, the top five and bottom five teachers determined the selection of the student subjects for testing the hypotheses. A one-way analysis of variance was applied to determine the difference in this frequency measure between these two groups of teachers.

Utilizing this selection procedure, the two hundred thirty students enrolled in one of these ten classes served as the sample for the two-by-three factorial design. The design schemata is presented in Figure 1. Students were assigned to the "treatment" cells (the treatments being selected, not induced) upon the bases of their mathematical ability (above average: stanine scores 7, 8, or 9; average: stanine scores 4, 5, or 6; below average: stanine scores 1, 2, or 3) and their teacher's relative ranked position (high: one of the top five rank positions; low: one of the bottom five rank positions). Only those students having scores on the three measures of pretest, post-test, and test of mathematical ability were assigned. A more detailed report of the stanine scores are presented in Appendix B.

Figure 1. Design for Testing Hypotheses

		Math Ability		
		Above Average	Average	Below Average
Teacher's Rank	High	N = 17	N = 61	N = 36
	Low	N = 11	N = 72	N = 33

Dependent Variable: Post-test
Covariate: Pretest

Data from the post-test measure of conditional reasoning ability was submitted to programs for correlation and for analysis of covariance for a two-way design, utilizing the pretest measure of conditional reasoning ability as the covariate.

Hypothesis 1. The frequency of utilization of the language of conditional logic by teachers of seventh grade mathematics is not related to their students' conditional reasoning ability.

Hypothesis 2. There is no relationship between mathematical ability and conditional reasoning ability.

Hypothesis 3. There is no relationship between a combination of frequency of utilization of the language of conditional logic by teachers and mathematical ability of students and student conditional reasoning ability.

The validity of these hypotheses was tested under the apriori .05 probability level. The data analysis was accomplished through the use of the MANOVA (a version of the Clyde Multivariate Analysis of Variance) computer program, and BMD program 02D.

CHAPTER IV: RESULTS

This chapter consists of two parts. The first part presents the data regarding the teacher verbal behavior analysis and the administration of the conditional reasoning tests. The second part presents the results of data analysis with regard to testing the hypotheses.

Teacher Utilization of Conditional Moves

Tapescripts of five lessons of each of the twenty randomly selected teachers of seventh grade mathematics were analyzed according to the teacher's frequency of conditional moves. The results of this analysis are presented in Table 4. The ten teachers used to identify the student subjects for testing the hypotheses are indicated in the table.

Student Conditional Reasoning Ability

The Cornell Conditional Reasoning Test--Form X was administered to the students enrolled in classes selected for the taping sessions. Table 5 presents the mean performance on the pre- and post-tests for each item group, component, and total for all students tested.

The conditional reasoning test performance of students assigned to the hypotheses testing design is illustrated in Table 6. Presented are the cell means and standard deviations for each of the teacher verbal behavior--mathematical ability combinations. Since growth and development of conditional reasoning ability were at the center of the

Table 4. Frequency of Conditional Moves by Original Sample of Twenty Teachers[a]

Teacher	Session I	II	III	IV	V	$\bar{X}$
[b] 1	48.5	35.5	47.5	32.0	39.5	40.6
[b] 2	41.5	40.0	29.0	64.0	6.0	36.1
[b] 3	33.5	44.0	29.0	23.0	34.5	32.8
[b] 4	32.0	23.5	23.5	31.0	23.5	26.7
[b] 5	33.0	32.0	16.5	28.0	15.0	22.9
6	14.0	21.0	25.0	12.5	29.0	20.3
7	18.5	37.5	12.0	22.0	8.0	19.6
8	20.0	17.5	29.0	9.5	18.0	18.8
9	15.0	21.0	8.5	26.0	18.5	17.8
10	22.5	22.0	13.0	10.0	21.0	17.7
11	24.5	19.0	15.0	12.5	15.0	17.2
12	9.5	20.5	24.0	15.0	12.5	16.3
13	26.0	7.5	15.0	12.0	13.5	14.8
14	20.5	15.0	10.0	15.0	10.0	14.1
15	10.5	10.5	8.5	23.0	17.5	14.0
[b] 16	14.0	14.5	16.0	15.0	7.5	13.5
[b] 17	16.5	8.5	20.0	12.0	16.0	12.6
[b] 18	30.0	19.5	13.5	10.5	10.0	11.3
[b] 19	15.5	5.0	20.5	12.0	5.0	9.6
[b] 20	13.0	10.5	9.5	5.5	3.0	8.3

[a] Based on the average totaled by the two analysts.

[b] Teachers used to identify student subjects for hypotheses testing.

Figure 2. Basic Principles of Conditional Logic

Principle	Symbolized Argument
1. Given an in-then sentence, the affirmation of the if-part implies the affirmation of the then-part.	If p, then q. p. Therefore q. Valid.
2. Given an if-then sentence, the denial of the if-part does not by itself imply the denial of the then-part.	If p, then q. Not p. Therefore not q. Invalid.
3. Given an if-then sentence, the affirmation of the then-part does not by itself imply the affirmation of the if-part.	If p, then q. q. Therefore p. Invalid.
4. Given an if-then sentence, the denial of the then-part implies the denial of the if-part.	If p, then q. Not q. Therefore not p. Valid.
5. The if-then relationship is transitive.	If p, then q. If q, then r. Therefore, if p, then r. Valid.
6. An if-then sentence implies its contrapositive.	If p, then q. Therefore, if not q, then not p. Valid.
7. The if-then relation is non-symmetric.	If p, then q. Therefore, if q, then p. Invalid.
8. Given an only-if sentence, the denial of the only-if part implies the denial of the major part.	p only if q. Not q. Therefore not p. Valid.

Figure 2 (continued)

9.	Given an only-if sentence, the affirmation of the major part implies the affirmation of the only-if part.	p only if q. p. Therefore q. Valid.
10.	The denial or affirmation of one part of an if-and-only-if statement implies respectively the denial or affirmation of the other part.	p, if, and only if, q. Not p. Therefore not q. Valid.
11.	Given an only-if statement, the affirmation of the only-if part does not by itself imply the affirmation of the major part.	p only if q. q. Therefore p. Invalid.
12.	Given an only-if sentence, the denial of the major part does not by itself imply the denial of the only-if part.	p only if q. Not p. Therefore not q. Invalid.

Table 5. Mean Performance on Pre- and Post-Test of Conditional Reasoning Ability for Students of All Twenty Teachers

		Pretest N = 459		Post-Test N = 451	
Item Group	Item Count	Mean	S. D.	Mean	S. D.
1	6	3.94	1.57	4.33	1.60
2	6	1.28	1.29	1.34	1.41
3	6	1.16	1.26	1.18	1.36
4	6	3.23	1.50	3.55	1.59
5	6	2.36	1.81	3.49	1.79
6	6	2.09	1.80	3.18	1.85
7	6	.63	1.05	1.07	1.40
8	6	3.75	1.68	3.87	1.73
9	6	4.05	1.54	4.47	1.39
10	6	2.05	1.80	3.10	1.86
11	6	2.01	1.74	3.06	1.77
12	6	.61	.98	.96	1.23
CF	48	18.58	6.29	22.80	5.93
SY	12	4.63	1.97	5.84	1.97
SU	12	3.57	2.37	4.97	2.54
NG	43	16.63	6.53	21.25	6.88
Total Test	72	27.19	9.70	33.60	9.37

Table 6. Performance on Conditional Reasoning Tests According to Teacher Rank for Frequency of Conditional Moves and Student Mathematical Ability

Teacher[a] Rank		Above Ave. Pre	Above Ave. Post	Average Pre	Average Post	Below Ave. Pre	Below Ave. Post	Total Ave. Pre	Total Ave. Post
High	$\overline{X}$	36.53	43.18	26.08	35.43	20.14	29.03	27.58	35.88
	SD	10.41	7.26	9.79	8.91	7.31	6.44	9.17	7.54
Low	$\overline{X}$	31.63	38.72	29.59	35.44	22.90	29.06	28.04	34.41
	SD	10.93	8.51	8.29	7.67	8.62	8.61	9.28	8.26
Total	$\overline{X}$	34.08	40.95	27.84	35.44	21.52	29.05		
	SD	10.67	7.89	9.04	8.29	7.97	7.53		

[a] For the ten selected teachers

question, indices of difficulty and pre- and post-test item group, component, and total mean difficulty differences were computed. Table 7 presents the results of these computations in terms of the student subjects having teachers with high rank (TWHR) and those having teachers with low ranking (TWLR). The mean difficulty indices represent the mean percentage of students answering correctly to the items included in the item group. If the index is large, then the items in that item group were easier. A negative change implies less difficulty from pretest to post-test administrations.

Reliabilities for the conditional reasoning test and subtests were calculated by Ennis and Paulus (21) and are presented in Appendix B.

ANALYSIS OF DATA

The first analysis required was a one-way analysis of variance between the two selected groups of teachers. Using the average number of conditional moves per lesson as the dependent variable, the summary of this analysis is presented in Table 8. The results assured that the two groups were significantly different ($p < .005$) with regard to frequency of conditional move utilization.

Table 7. Change in Mean Difficulty Indices Between Pre- and Post-Test Measures for TWHR and TWLR Students[a]

Item Group	Test	N =	TWHR 114	TWLR 116
1	Pre		64.0	66.5
	Post		71.5	70.7
	Change		-7.5	-4.2
2	Pre		23.0	19.0
	Post		26.8	24.3
	Change		-3.8	-5.3
3	Pre		22.4	18.4
	Post		23.8	20.0
	Change		-1.5	-1.6
4	Pre		53.1	51.9
	Post		58.9	58.0
	Change		-5.8	-6.2
5	Pre		33.2	44.4
	Post		57.6	61.8
	Change		-24.4	-17.4
6	Pre		30.0	38.2
	Post		51.6	54.9
	Change		-21.6	-16.7
7	Pre		10.8	10.3
	Post		20.0	22.8
	Change		-9.2	-12.5
8	Pre		62.7	61.8
	Post		67.7	63.2
	Change		-5.0	-1.4
9	Pre		66.1	67.2
	Post		73.1	73.7
	Change		-7.0	-6.5
10	Pre		30.7	37.8
	Post		54.8	52.7
	Change		-24.1	-14.9

Table 7 (continued)

Item Group	Test Test	N =	TWHR 114	TWLR 116
11	Pre		27.9	37.1
	Post		52.5	50.7
	Change		-24.6	-13.6
12	Pre		5.6	12.2
	Post		17.7	18.7
	Change		-12.1	-6.5
CF	Pre		36.6	39.9
	Post		48.3	47.8
	Change		-11.7	-7.8
SY	Prw		36.2	38.9
	Post		50.0	48.8
	Change		-13.8	-9.9
SU	Pre		28.9	30.1
	Post		44.8	41.1
	Change		-15.9	-11.0
NG	Pre		36.8	39.3
	Post		50.8	48.8
	Change		-14.1	-9.5
Total Test	Pre		35.5	38.3
	Post		48.1	47.4
	Change		-12.6	-9.1

[a] A negative change represents less difficulty on the post-test since a high index indicates less difficulty.

Table 8. Analysis of Variance for Selected Teachers (TWHR and TWLR)

Source	df	SS	ms	F
Between Groups	1	10,883.3	10,883.3	22.3*
Within Groups	8	3,895.0	487	
Total	9	14,878.3		

* $p < .005$

Each of the hypotheses of the study was stated in the null form. The alpha level chosen was the .05 probability level for significance. The analysis basic to all three hypotheses was a two-way multivariate analysis of covariance. Table 9 presents the summary of this analysis for each of the three variables (teacher frequency of conditional moves rank, student mathematical ability and interaction). Univariate analyses are also presented but the probability levels must be reported for the sample, and also for the population. The probability levels cited for the population are those which allow others to generalize the results. They represent an inflation of the probability levels presented for the sample using the equation $x_p = 1 - (1 - x_s)^n$ where x_p and x_s are the population and sample probability levels (alpha risks) respectively, and n represents the number of univariate analyses. This inflation is necessitated due to the fact that the item groups are not independent of the total test.

The mean scores for the ten classes involved were adjusted for the covariate of pretest performance. Further analysis was conducted by using the two covariates of pretest performance and mathematical ability to adjust the TWHR and TWLR group means. Using mathematical ability as a covariate did not contribute to the adjustment of these means. So for the sake of parsimony, only the pretest as a covariate was used to adjust post-test means. These adjusted means are presented in Table 10. Utilizing these means, coefficients of correlation were calculated for the total post-test score and each item group post-test score. These coefficients are presented in Table 11.

Table 9. Summary of the Multivariate and Univariate Analyses of Covariance

Source: Between Teacher Verbal Behavior Groups (TWHR and TWLR)

Multivariate Test

Test of Roots	F	p less than
1 through 1	1.318	0.184

Univariate Tests

Criterion	F (1,223)	ms.	For Sample p less than	For Population p less than
Total Test	4.933	189.734	0.027	
Item Group				
1	1.411	3.159	0.236	.987
2	0.132	0.272	0.717	.999
3	0.610	1.093	0.435	.999
4	1.117	2.160	0.292	.996
5	0.004	0.009	0.948	.999
6	0.800	1.804	0.372	.999
7	1.003	2.047	0.318	.998
8	8.785	20.329	0.003	.047
9	0.332	0.596	0.565	.999
10	2.911	5.773	0.089	.775
11	1.911	4.084	0.168	.947
12	0.408	0.621	0.524	.999
CF	1.878	33.903	0.172	.951
SY	2.645	6.602	0.105	.837
SU	7.096	26.597	0.008	.121
NG	6.552	159.094	0.011	.162

Table 9 (continued)

Source: Between Mathematical Ability Groups

<u>Multivariate Test</u>

Test of Roots	F	p less than
1 through 1	1.620	0.017

<u>Univariate Tests</u>

Criterion	F (2,223)	<u>ms.</u>	For Sample p less than	For Population p less than
Total Test	6.057	232.963	0.003	
Item Group				
1	0.133	0.299	0.875	.999
2	5.150	10.625	0.007	.106
3	10.820	19.374	0.001	.016
4	0.045	0.086	0.956	.999
5	3.086	6.215	0.048	.545
6	0.686	1.547	0.505	.999
7	7.757	15.830	0.001	.016
8	0.110	0.254	0.896	.999
9	0.234	0.419	0.792	.999
10	0.560	1.111	0.572	.999
11	1.779	3.802	0.171	.950
12	1.518	2.311	0.221	.982
CF	5.218	94.172	0.006	.092
SY	0.960	2.395	0.385	.999
SU	4.713	17.665	0.010	.149
NG	1.473	35.754	0.232	.985

Table 9 (continued)

Source: Interaction of Teacher Verbal Behavior and Mathematical Ability

Multivariate Test

Test of Roots	F	p less than
1 through 1	0.835	0.733

Univariate Tests

Criterion	F (2,223)	ms.	For Sample p less than	For Population p less than
Total Test	0.030	1.160	0.970	
Item Group 1	1.448	3.243	0.237	.987
2	4.349	8.972	0.014	.202
3	2.965	5.310	0.054	.589
4	0.030	0.059	0.970	.999
5	2.791	5.621	0.063	.647
6	1.012	2.281	0.365	.999
7	0.644	1.314	0.526	.999
8	0.352	0.816	0.703	.999
9	2.392	4.288	0.094	.794
10	0.331	0.656	0.719	.999
11	0.973	2.080	0.379	.999
12	2.193	3.337	0.114	.856
CF	0.111	1.995	0.895	.999
SY	0.173	0.432	0.841	.999
SU	0.080	0.300	0.923	.999
NG	0.289	7.025	0.749	.999

Table 10. Post-Test Means Adjusted for the Pretest as Covariate

	Mathematical Ability			
	Above Average	Average	Below Average	Total Average
TWHR	37.665	35.854	32.835	35.171
TWLR	35.997	33.874	31.293	33.341
Total	37.010	34.782	32.097	

Table 11. Correlations Between Post-Test Total and Subtest Scores and the Factors of Mathematical Ability and Teacher Frequency of Conditional Moves

Item Group	Frequency of Conditional Moves	Mathematical Ability
1	.220	-.070
2	.060	.450
3	.128	.646
4	.212	.042
5	-.077	.076
6	.041	-.095
7	-.219	.521
8	.422	.046
9	.118	-.052
10	.329	-.133
11	.273	.184
12	-.145	.244
CF	.267	.446
SY	.348	.161
SU	.536	.404
NG	.519	.207
Total	.429	.473

Notes: 1. These are based upon the adjusted means after the removal of covariate of pretest performance.

2. A correlation that is significant ($p < .05$) is underlined.

The decision to reject or not to reject the individual hypotheses was based on the analyses of data presented on the preceding pages.

Hypothesis 1. The frequency of utilization of the language of conditional logic by teachers of seventh grade mathematics is not related to their students' conditional reasoning ability.

The decision to reject this hypothesis was supported by the result of the analysis of covariance and the subsequent correlation coefficient calculations. After adjustment for the covariates of pretest total score and mathematical ability there were significant differences between the teacher verbal behavior groups on the total test ($p < .072$) and two item groups (8 and SU; $p < .003$, $p < .008$). The corresponding coefficients of correlation for these three measures were .429, .422, and .536 respectively.

Hypothesis 2. There is no relationship between mathematical ability and conditional reasoning ability.

Hypothesis 2 was rejected for the same reasons given for rejecting Hypothesis 1. After adjusting for the covariate of pretest total score, significant differences existed between the mathematical ability levels. Comparisons of the adjusted means for these levels on the total test and item groups 2, 3, 5, 7, CF, and SU, all of which exhibited significant differences ($p <$ at least .048) for this variable were not calculated. This decision was based upon the fact that the study was descriptive, not experimental. Instead, the means were used to calculate coefficients of correlation presented in Table 11. For the measures exhibiting significant differences, the coefficients were

.473 (total post-test), .450, .646, .076, .521, .446, .404 (item groups 2, 3, 5, 7, CF, and SU respectively).

Hypothesis 3. There is no relationship between a combination of frequency of utilization of the language of conditional logic by teachers and mathematical ability of students and student conditional reasoning ability.

This hypothesis could not be rejected for the total test or item group measures. The multivariate test F-ratio was so small ($p < .733$) that none of the univariate F's could be considered significant.

CHAPTER V: SUMMARY AND CONCLUSIONS

In this chapter a summary of the study, an interpretation of the results, conclusions, and recommendations for future studies are presented.

Statement of the Problem and Procedures

This study made an attempt to integrate the research domain of analysis of teacher verbal behavior and the body of knowledge emanating from the psychological and linguistic analyses of the growth and development of children's logical abilities. This attempt took the form of answering the general empirical question of whether or not the frequency of teacher utilization of the language of conditional logic is a significant variable in shaping student ordinary language into the useful conditional reasoning component of critical thinking.

A two-by-three factorial design was utilized to ascertain the relationship between the frequency of teachers' utilization of the language of conditional logic and their students' conditional reasoning ability.

Prior to the beginning of school, twenty teachers of seventh grade mathematics were randomly selected from a large metropolitan school system. Students enrolled in one intact class of each teacher were administered the Cornell Conditional Reasoning Test--Form X during the first month of school. Five lessons presented to this same class for each of the twenty teachers were audio-taped and analyzed according to the teacher's frequency of conditional moves. This measure was determined by two analysts for each transcribed lesson, utilizing a modified version of the Smith and Meux (61) classification system.

The subsequent rank positions assigned to each teacher served to identify the student subjects who were administered a post-test of the same conditional reasoning test just prior to the close of the first semester. The mathematical ability of each student was determined according to measures gained from the school system's administration of the California Comprehensive Arithmetic Test--Level 3 during the second month of school. Students were assigned to the six groups of the two-by-three factorial design illustrated by the the following:

		Mathematical Ability		
		Above Average	Average	Below Average
Teacher Rank	High	N = 17	N = 61	N = 36
	Low	N = 11	N = 72	N = 33

SAMPLE: Students of teachers in the top or bottom five rank positions.

DEPENDENT VARIABLE: Post-test scores of conditional reasoning ability adjusted for the pretest as a covariate.

INTERPRETATION OF RESULTS

General Qualifications

Two important qualifications should be kept in mind as one reads this section. First, since the students were not randomly assigned to the cells, other factors may be affecting the outcome. For example, reading abilities, intelligence, and other variables may be different between the treatment groups. This fact is not crucial to the hypotheses since no causal inferences are made. But it has to be considered if results of future studies differ with regard to the degrees of relationship as expressed by the correlation coefficients which are reported herein.

Second, the growth in conditional reasoning abilities for the groups of TWHR and TWLR students as evidenced from improvement in scores between pre- and post-test measures could be due to several other causes.

Possible causes of improvement in scores are:

1. The taking of logic tests that result in the learning of logic or in the learning of how to take this and other tests (test-wiseness).
2. Other school influences.
3. Influences outside of school.

These factors are somewhat related to the first qualification discussed above. They are presented here more to indicate areas for improvement in designing future studies than as threats to internal validity of this study.

The first factor is self-explanatory and is always a concern of a pretest-post-test design. Other school influences could include the verbal behavior and subject matter presentations of the students' non-mathematics teachers. The verbal behavior of fellow students could be having an effect as well. In the past, studies have shown that most of the talking in the classroom is produced by teachers but peer verbal behavior might still be considered as a cause.

In a similar manner, the verbal behavior of the parent could be a significant variable in the development of logical reasoning ability. The type of verbal behavior presented in books (read for pleasure or for school assignments) would be another example of this type of possible cause.

Hypothesis 1

The relationship between students' conditional reasoning ability and their teacher's frequency of conditional moves was found to be significant for various scores on the post-test. Amplification and qualification of these relationships follow.

A. Total Scores

The situation in comparing total scores can be seen in various ways. One way is through visual comparison of the mean pre- and post-test total scores presented in Table 6. No large improvement differences are noted between the cells. There is just a slight difference between teacher rank groups in favor of the students' having teachers with high rank positions (averages 8.30 and 6.37 for TWHR and TWLR respectively).

Another measure of this growth relative to the two teacher verbal behavior groups is presented in Table 7. Notice that although the TWLR's had less difficulty on the pretest than the TWHR's, they had more difficulty on the post-test when compared with the TWHR's. The degree of change might be an indication of greater growth by the TWHR's but it might also be an indication of regression toward the mean.

The summary of the analysis of covariance (Table 9) indicates a significant difference ($p < .027$) favoring the TWHR's. This is evident from observation of Table 10 which illustrates the adjusted means for the two covariates of mathematical ability and pretest.

The degree of relationship between teacher frequency of conditional moves and their students' conditional reasoning ability is expressed by the correlation coefficient of .429 in Table 11. Being significant at the .05 level, Hypothesis 1 must be rejected for the post-test measure.

B. Item Group Scores

As exhibited by the tables, the situation is roughly the same as viewed through the component scores. The mean difficulties on the pretest favored the TWLR's. The TWLR's had less difficulty on eleven of the sixteen item group pretest measures than the TWHR's. On seven of these same eleven item group post-test measures, the TWLR's had greater difficulty than did the TWHR's. The degree of change for all but four of the item groups favored the TWHR's. Regression may be involved but it seems rather difficult to accept this alternate hypothesis for the differences in change in difficulty indices. The TWHR's have performed better on the post-test, significantly so for at least two of the item groups as exhibited in Table 9.

Item group eight involved the principle having the form "p only if q, not q : p". The difference is reported significant at the .003 level but the multiple analyses of covariance necessitates inflation to the .047 level. The seemingly significant .008 level for the SU variable really is not since inflation yields a probability level of .121.

However, the coefficient in Table 11 for the component of SU, which refers to items of suggestive content, is quite high (r = 0.536) relative to the others. It is also significant at the .05 level. This would lead one to interpret this as indicating that the TWHR's were not trapped by the items which were emotionally based. This appears to say that the TWHR's were more concerned with the logical form rather than the content in contrast to the TWLR's.

The other content type which some researchers have found to be difficult for younger subjects (cf. Roberge (56), Hill (32)) are those involving negation. This group of items is represented by NG. Notice that the probability level of .011 is listed for this group type in the analysis of covariance. Inflation of this sample alpha-risk puts it above the apriori alpha of .05.

But Table 11 indicates a relationship almost as strong as the SU group and stronger than that for the total test. Again this favors those students with teachers using greater frequency of conditional moves. An investigation of the tapescripts of the teachers does not yield evidence to support a statement that the negative is used with any regularity in conditional moves by any of the teachers. This finding is unaccounted for by the analysis of tapescripts.

Hypothesis 2

It appears that mathematical ability is a better predictor of conditional reasoning ability than membership in a class whose teacher uses a greater frequency of conditional moves. This might also be accounted for because of the positive relationship existing between mathematical ability and intelligence. Intelligence, it was noted above, is related to logical reasoning ability, so there could be a transitive situation involved.

A. Total Scores

Similar to Hypothesis 1, visual comparison of the mean pre- and post-test scores present a rough unsophisticated comparison for the mathematical ability levels. Again, no large improvement differences are observed (6.87, 7.60, 7.53 for above average, average, and below average respectively). However, there was a significant difference ($p < .003$) for the mathematical ability variable as a result of analysis of covariance (see Table 9). Typically in the testing of a causal hypothesis, post hoc procedures would involve comparisons of the three level means. This not being the case for this study, further information is supplied by Table 11. The coefficient of correlation is registered as .473, significant at the .05 level.

B. Item Groups

Students with greater mathematical ability scored higher on several of the item groups as well as the total test. Table 9 yields evidence of this relationship for item groups 2, 3, 7, and CF. The interesting feature of the principles tested in item groups 2, 3, and 7 is that they express what are called the basic fallacies of conditional logic (as opposed to the basic validities). Their basic forms are as follows:

Item Group	Title	Form	Answer
2	Fallacy of denying the antecedent	If p, then q not p : not q	Maybe
3	Fallacy of asserting the consequent	If p, then q q : p	Maybe
7	Fallacy of asserting the converse	If p, then q : if q, then p	Maybe

Arguments in these forms can only be answered "maybe." Their truth-status is not known from the given premises.

About fallacious arguments, Aylesworth and Reagan (2) write, "One of the problems with fallacious arguments is that they do often convince people." (2:69). ". . .If we are to encourage learners to develop skills in critical thinking, part of our task is to aid them in identifying and avoiding mistakes in reasoning." (2:33). This finding then is quite interesting in view of the relatively high correlation coefficients of .450, .646, and .521. This may be interpreted to mean that students with lower mathematical ability ". . .seem better able to tell that something which follows, does follow; than that something which does not follow, does not follow." (21:V-30).

Interesting too is the finding of Ennis and Paulus (21) that the fallacy principles are ". . .the most difficult at ages 10 - 12, there is great improvement in knowledge of these principles as students grow older." (21:V-30). After teaching logic to students in grades 5, 7, 9, and 11, they found that these item groups were the only ones for which they were able to obtain significant differences as compared to those not taught. And it only occurred at the eleventh grade.

Whereas the other significant correlation coefficients might be due to the relationship between intelligence and mathematical ability, these three must be held in greater esteem.

The CF component (concrete familiar items) was found to be significant at the .006 level after analysis of covariance. Inflation does not yield significance ($p < .09$). The coefficient of correlation of .446 must be considered in reference to the other content types. Notice a fairly high coefficient for the SU (suggestive content) of .404 and the lower one for NG of .207. Nothing can be said about the non-significant SY component. Basically these coefficients indicate that students with high mathematical ability do better on item types in the following order: concrete familiar content, suggestive content, and negative content. They also indicate that mathematical ability is a fairly good predictive variable for the item types of concrete familiar and suggestive content. Thus Hypothesis 2 must be rejected with qualification to item content types and principles under consideration.

Hypothesis 3

Finding no significance for any interaction of teacher utilization of conditionals combined with student mathematical ability came as a surprise to the investigator. This lack of significance might be explained, at least partially by considering Piaget's findings. Piaget says that there is a limit to the logical abilities of children for a given age group. Maybe the students with high mathematical ability had reached this limit with respect to their age. It was the particular combination of high mathematical ability and high frequency of conditional moves by the teacher that was apriorially considered as a combination that would yield significance. But without significant differences, Hypothesis 3 cannot be rejected.

One further word about the rejection of Hypotheses 1 and 2 seems in order. It was felt that initial differences in mathematical ability between the two groups TWHR and TWLR might be loading in favor of the TWHR group. Table 12 presents the distribution of student mathematical ability stanine scores for each cell of the design. Since the TWLR group above average mathematical ability cell mean is higher than the mean of the TWHR group, and the total group means of mathematical ability differ by only .08, it seems that this alternate hypothesis is to be rejected. That is, the mathematical ability does not seem to be loading in favor of the TWHR group.

Another alternative hypothesis for the strength of the relationship found between the teacher frequency of conditional moves and their students' conditional reasoning ability has been offered by one of the teachers. At the time of the first administration of the conditional reasoning test he commented that he felt that his students would have difficulty reading the items. Although he later said that the students did not have great difficulty the fact remains that the criterion measure involved reading ability.

Table 12. Distribution of Student Mathematical Ability Stanine Scores for TWHR's and TWLR's

	Above Average		Average		Below Average		
	Stanine	N	Stanine	N	Stanine	N	$\bar{X}$
	9	4	6	18	3	26	
TWHR	8	2	5	18	2	6	4.57
	7	11	4	25	1	4	
	$\bar{X}$ = 7.59	17	$\bar{X}$ = 4.89	61	$\bar{X}$ = 2.61	36	
	9	1	6	17	3	21	
TWLR	8	6	5	27	2	8	4.49
	7	4	[illegible]	29	1	4	
	$\bar{X}$ = 7.72	11	$\bar{X}$ = 4.84	73	$\bar{X}$ = 2.33	33	
	$\bar{X}$ = 7.64	28	$\bar{X}$ = 4.86	134	$\bar{X}$ = 2.57	69	4.53

In order to determine the possibility of loading in favor of the TWHR's, scores on the California Comprehensive Reading Test were obtained for the student subjects. Table 13 presents the total test score cell means for teacher ranks crossed with reading ability (above average: stanine scores 7, 8, 9; average: stanines 4, 5, 6; below average: stanines 1, 2, 3).which have been adjusted for the pretest measure as a covariate. Since the question deals with reading ability, certainly if there was a loading factor it would have occurred for the above average groups. That is, the above average groups should not have had difficulty reading the items. Therefore, if it was reading ability and not the teacher verbal behavior, then the mean for the TWHR's would not be significantly different from that for the TWLR's. The means differ by almost three points and this is significant ($p < .05$). As far as loading in favor of one group, Table 14 presents the distribution of student reading abilities for each cell. The same situation is true for reading as it was for mathematical ability. There does not appear to be a loading in favor of the TWHR's.

This finding also sheds some light on another area of concern. It has been argued that the student's ordinary language is shaped by the teacher's use of conditional moves. The measure of the student's reasoning ability was based on a written test in which the student's reading ability as well as his use of language was involved. It might be argued that this measure is more a measure of reading ability than it is of logical reasoning ability. This led to the calculation of correlation coefficients for reading ability and test scores. For the total test, $r = .671$, which is significant ($p < .01$). Significant

Table 13. Mean Post-Test Performance on the Conditional Reasoning Test for TWHR and TWLR Students According to Reading Ability After Adjustment for Pretest Performance

	Reading Ability			
	Above Average	Average	Below Average	$\bar{X}$
TWHR	38.975 (N=23)	35.786 (N=66)	29.819 (N=25)	35.121 (N=114)
TWLR	36.157 (N=12)	34.626 (N=65)	30.329 (N=38)	33.390 (N=116)
Total Mean	37.957	35.210	30.127	

Table 14. Distribution of Student Reading Ability Stanine Scores for TWHR's and TWLR's

	Above Average		Average		Below Average		
	Stanine	N	Stanine	N	Stanine	N	$\bar{X}$
TWHR	9	5	6	19	3	20	
	8	8	5	17	2	3	
	7	10	4	30	1	2	
	$\bar{X} = 7.783$	23	$\bar{X} = 4.833$	66	$\bar{X} = 2.720$	25	4.964
TWLR	9	1	6	18	3	26	
	8	2	5	26	2	7	
	7	10	4	21	1	5	
	$\bar{X} = 7.307$	13	$\bar{X} = 4.953$	65	$\bar{X} = 2.552$	38	4.431

correlations were also found for the item groups of concrete familiar content ($r = .648$), suggestive content ($r = .521$), and negative content ($r = .516$).

This supports the argument that the test measures reading ability. It also supports the work of those who have developed language enrichment programs with the intent to enhance logical reasoning ability (eg. Bereiter and others). But the comparison of the reading abilities between the TWHR's and TWLR's presented in Table 14 leads one to believe that the test measures something in addition to reading ability. The way in which the test has been constructed leads this investigator to believe that it is valid (both content and construct-wise), and is measuring conditional reasoning ability.

CONCLUSIONS

This study set out to begin construction of a bridge between descriptive analyses of teacher verbal behavior and student logical reasoning development. One guy wire has been placed. The results of this study indicate a positive relationship between teacher utilization of conditional moves and student conditional reasoning ability. This is not to say that such utilization will cause or in any way affect this ability. The surest way to fall into the chasm is to place too much weight on the bridge. The weakness of the bridge in its present form is to be realized. More is to be said in relation to bolstering it in the section entitled "Recommendations."

The relationship existing between teacher frequency of conditional moves and student logical abilities is differential in nature.

Since there were twelve basic principles of conditional logic and four content types tested, this is a logical finding. In particular this relationship was found to exist for the total test score and two item group scores. The most interesting of the latter was the negative component.

The ability to recognize fallacious arguments as well as the ability to perform well on a test of conditional reasoning is positively related to mathematical ability.

For the benefit of future studies, it can be concluded that the method of "microcriteria of effectiveness" can be used effectively in analyzing teacher verbal behavior. The move of analysis in this direction appears to hold a wealth of potential, especially in view of the findings.

Also, for future studies, it is now known that the length of a transcription of verbal behavior is not closely related to the length of time it takes to speak. And random selection of twenty teachers (possibly less) should be sufficient to find significant differences in the frequency of linguistic pattern utilization.

RECOMMENDATIONS

Recommendations relative to this study will be considered in two parts: those for future research efforts and those for educational practices.

Future studies dealing with teacher verbal behavior analyses and those whose concern is logical reasoning ability development may be able to benefit from the findings. First, this study indicates that the variables of teacher frequency of conditional moves and student mathematical and reading abilities should be controlled in studies measuring student logical reasoning abilities. Studies cited in chapter two of this report in which mthods and materials were tested relative to student critical thinking abilities, did not exhibit significant differences. If the variables found to be related to logical reasoning ability in this study had been considered and controlled, the results might have been different. For example, significant differences in logical reasoning might not have magically appeared but the explanation for their absence would have been clearer.

Another explanation for non-significant findings of these studies would be the variables associated with adventitious learning. The results of this study indicate that future studies dealing with adventitious learning can expect to yield evidence of broader implications for educational practices. In addition to the learning of conditional reasoning, other cognitive developments may be found to be influenced by adventitious learning.

Typically a descriptive study should be followed by one of an experimental nature. This may not be possible in this case due to the very nature of adventitious learning. The learning stimulus being a natural quality of teacher language may make manipulation next to impossible. Not that teacher verbal behavior itself cannot be modified, but to do so would have an effect of increasing threats to both internal and external validity. Modification of teacher verbal behavior would tend to enter biases plus the incidental instructional situation would be lost. It may also be the case that an artificially induced increase in the frequency of conditional moves would not have the same degree of effectiveness as that of a n tural use of conditional moves.

This study does indicate that the eyployment of the technique of microcriteria of effectiveness can contribute to the analyses of teacher verbal behavior whether or not the analyses are conducted within the realm of adventitious learning. Concentrating on only one specific aspect of the teacher's verbal behavior facillitates both analyses and interpretation. If a theory of adventitious learning is to be developed the employment of this technique is highly recommended.

For future procedural decisions regarding the unit of discourse to be used in measuring the utterances of teachers, the pedagogical move and not the length of transcription should be considered. This study found that the move was well defined and easily understood by analysts. The half-line is well defined but not related to the length of time it takes to speak. For adventitious learning studies, the frequency of the linguistic pattern under observation is much more important than its transcription length.

To make recommendations for changes in educational practices steps beyond the data. But awareness of relationships establishes partial support for opinions regarding the teaching act.

Adventitious learning of logic suggests several implications for teaching. First, teachers should be made aware of the effect that their utilization of language may have on their students. If they decide that it would be advantageous for them to modify their verbal behavior in order to increase their frequency of conditional moves, they would find support from this study. Likewise, teacher educators would do well to consider the need for more concern for teacher use of language. Attempts should be made to increase the frequency of logical operations of teachers through inclusion of discussion and practice of these moves in training programs.

Authors of textbooks and instructional materials should consider including contexts which would provide a natural opportunity for teachers to utilize the conditional move. For example, in mathematics, problems could be presented in the following format:

$$6 + 4 = 10 \implies 10 - \square = 6$$

The teacher could stress using one sentence to provide information to help solve the problem implicit in the other sentence. In doing so, he may be found to have increased his frequency of conditional moves.

One last recommendation seems in order. Although adventitious learning had been discussed at great length in this report and several cognitive factors may develop as a result of this type of learning, it is not suggested that all things can be learned in this manner. There is no replacement for formal or intentional learning which occurs in our educational institutions. The hope is that the presentation of materials by teachers will be enhanced by greater knowledge of adventitious learning. It is to this end that this study has been conducted.

APPENDIX A

INSTRUMENTS USED IN THE STUDY

THE CORNELL CONDITIONAL REASONING TEST--FORM X (19)

The test contains seventy-two items in twelve item groups of six items apiece. Each group of six items embodies a principle or combination of principles of conditional logic. (The principles are listed along with their logical forms in Figure 2.) The six items within any group are scattered so that no two appear on any one page. Each item group contains four concrete familiar items, one symbolic item, and one suggestive item. These content types are presented on page 11.

There are three choices for each item-- YES, MAYBE, AND NO-- which are explained in the directions.

Individual item group reliabilities are presented in Table 16.

THE CALIFORNIA COMPREHENSIVE ARITHMETIC TEST--LEVEL 3 (16)

This test consists of three parts: Computation, Concepts, and Applications. Each part is described in the following section. The average score on each part was used to gain a total test score and corresponding stanine score for each student. These stanine scores were based on national averages.

Part I. Computation

Forty-eight items are equally distributed among the four fundamental operations of addition, subtraction, multiplication and division.

Part II. Concepts

Presented are thirty items measuring the ability of the student to recognize and/or apply the appropriate concept and technique; the ability to convert concepts expressed in one numerical, verbal, or graphic form to another form; the ability to comprehend numerical concepts and understand their interrelationships; and the ability to organize all facts in more complex questions. The content includes a variety of categories of items based on the number system (integers, fractions, percents, decimals, exponents), measurement (money, time, length, area, volume, weight, scientific), algebra, geometry, statistics, and logic.

Part III: Applications

Presented are twenty items in which the emphasis is placed upon problem-solving. The tasks required in this part involve the ability to comprehend the problem, select the appropriate method for solving, organize all facts in total problems of a more complex nature, and solve for the correct answers.

WATSON-GLASER CRITICAL THINKING APPRAISAL (66)

The Critical Thinking Appraisal is designed to provide problems and situations which require the application of some of the important abilities involved in critical thinking. It can serve both as a test to measure several of the major factors involved in ability to think critically and as a tool to aid in developing that ability. Its items are mostly of a realistic type, involving problems, statements, arguments, and interpretation of data similar to those which a citizen in a democracy might encounter in his daily life as he works, reads the newspaper, hears speeches, participates in discussions on various issues, et cetera.

The subtests are as follows:

Test 1. Inference (twenty items). Designed to sample ability to discriminate among degrees of truth or falsity or probability of certain inferences drawn from given facts or data.

Test 2. Recognition of Assumptions (sixteen items). Designed to sample ability to recognize unstated assumptions in given assertions or propositions.

Test 3. Deduction (twenty-five items). Designed to sample ability to reason deductively from given premises; to recognize the relation of implication between propositions; to determine whether what seems an implication or necessary inference between one proposition and another is indeed such.

Test 4. Interpretation (twenty-four items). Designed to sample ability to weigh evidence and to distinguish between unwarranted generalizations and probable inferences which, though not conclusive or necessary, are warranted beyond a reasonable doubt.

Test 5. Evaluation of Arguments (fourteen items). Designed to sample ability to distinguish between arguments which are strong and important to the question at issue and those which are weak and unimportant or irrelevant.

THE LANGUAGE OF CONDITIONAL LOGIC: A CLASSIFICATION SYSTEM[a]

The entries contain an antecedent, that is, the conditional part of a statement. In the sentence "When it rains, the streets are wet" the phrase "When it rains" is the antecedent. The phrase "the streets are wet" is the consequent. The entries which make up this category give an antecedent. Sometimes they give both an antecedent and a consequent. But they never contain a consequent alone.

An example of an entry containing an antecedent only is: "If that diagonal (in rhombus) is given as 12 and this angle is 60, what is the angle at C and at A?" The antecedent is "If that diagonal is given as 12 and the angle is 60". The consequent asked for by the question is the size of the angle at C and A. In all cases where the antecedent alone is given, the entry requires that the consequent--effects, result, outcome, etc.--be supplied as the answer.

Consider an example of an entry containing both an antecedent and a consequent: "If we multiply everything by 1, we still get 14". The phrase "If we multiply everything by 1" is the antecedent, and "we still get 14" is the consequent.

CRITERIA FOR CLASSIFYING ENTRIES

(Examples with " * " were obtained from excerpts of tapescripts acquired in a sevevth grade mathematics class taped on 5/6/71.)

---

[a] Adapted from Smith and Meux (61).

1. Soliciting a result:

   The antecedent gives a condition or operation, and the question uses expressions like "what happens," "effect," "influence," "result," "get," "gain," "give," ect.

   *1.1 "What happens when you multiply by ten?"

   *1.2 "Multiplying by ten does what to your decimal point?"

2. Soliciting an action:

   The antecedent gives a condition, and the question uses such expressions as "what do you do," "what do we do," "what should we write," "where do we put it," etc.

   *2.1 "What do we do when we multiply by ten?"

   *2.2 "What has to be done if the decimal is in front of the 2?"

3. Soliciting an identification:

   The antecedent gives a condition, and the question asks how something may be identified, explained, classified, defined, called, compared to something else, etc.

   *3.1 "If you have this zero here, it's what?"

   *3.2 "This ten to the negative two, what are we going to call it?"

   *3.3 "If the exponent up here is negative, then it means what?"

   *3.4 "When you multiply by a hundred, what's that have to do with multiplying by ten?"

4. Soliciting a quantitative answer:

   The antecedent gives a condition and the question uses such expressions as "how much," "how long," "how many," etc.

   *4.1 "If you put the decimal point here, how many numbers are behind the decimal point?"

*4.2 "If this is 3 inches and this is 5 inches, how long is the whole thing?"

5. Stating a result:

The antecedent gives a condition and the consequent refers to what happens, what the result is, what the answer is, etc.

*5.1 "If you drop it (decimal point) straight down, you get something that's wrong."

*5.2 "If you write it any other way, it'll still work out."

*5.3 "If we multiply by two that's going to get 14 hundredths."

6. Stating an action:

The antecedent gives a condition and the consequent refers to what has to be done, what should be done, etc.

*6.1 "Where you have a thing like this, write it down and do your multiplication."

*6.2 "If you have a specific problem, come see me."

*6.3 "If you didn't realize this was multiplication by a power of ten, you could have written out 263 point 5 then under it point 0, 1."

*6.4 "When your exponent up here is positive, you're moving your decimal point to the right."

7. Stating an identification:

The antecedent gives a condition and the consequent refers to a classification, a definition, a name, etc.

*7.1 "If it's the first place after the decimal, it's tenths."

*7.2 "When you have this zero here, it's twenty."

*7.3 "If you multiply it by 2 first, and then by 10, it's the same thing as multiplying it by twenty."

8. Stating a quantification:

The antecedent gives a condition and the consequent refers to length, length of time, rate, how many, etc.

*8.1 "If you subtract, you find this board is 4 inches longer."

*8.2 "When you travel for 4 hours, you go 160 miles."

APPENDIX B

TABLES

Table 15. Teacher Ranks Based on Verbal Behavior Analysis and Watson-Glaser Scores

Teacher	Cond. Moves/Lesson	Cond. Half-Lines/ Lesson	Cond. Half-Lines/ Total Half-Lines	W-G Score
1	1	1	2	18
2	2	2	1	16
3	3	4	4	7
4	4	3	5	3
5	5	5	8	12
6	6	9	10	8
7	7	12	12	[a]
8	8	6	7	14
9	9	7	9	4
10	10	13	19	1
11	11	10	13	9
12	12	11	17	[a]
13	13	18	16	11
14	14	14	6	6
15	15	16	14	15
16	16	15	15	10
17	17	17	11	2
18	18	8	3	13
19	19	19	18	5
20	20	20	20	17

[a] Teacher declined to respond

Table 16. Test-Retest Reliability Estimates on the Cornell Conditional Reasoning Test[a]

Item Group	Mean	S. D.	r
1	4.5	1.3	.56
2	1.8	1.6	.48
3	1.7	1.4	.34
4	4.0	1.5	.27
5	3.9	1.6	.58
6	3.8	1.6	.40
7	1.6	1.7	.38
8	4.9	1.2	.57
9	4.6	1.2	.38
10	4.2	1.7	.54
11	3.9	1.4	.39
12	1.1	1.4	.55
CF	27.1	5.5	.63
SY	6.6	1.9	.50
SU	5.9	1.9	.40
Total	33.6	9.3	.85

[a] Reported by Ennis and Paulus (21). Total reliability was calculated using data from present study.

Table 17. Change in Mean Difficulty Indices From Pre- to Post-Test for All Students Taking Both

Item Group	Pretest	Post-Test	Change
1	65.6	72.7	6.6
2	23.3	22.5	-0.8
3	19.3	19.6	0.3
4	53.7	59.3	5.6
5	39.4	58.1	18.7
6	34.9	53.2	18.3
7	10.5	17.9	7.4
8	62.5	64.4	1.9
9	67.5	74.6	7.1
10	34.2	51.7	17.5
11	33.5	51.0	17.5
12	10.1	16.0	5.9
CF	39.7	47.6	7.9
SY	38.5	48.7	10.2
SU	29.8	41.5	11.7
NG	40.6	40.5	8.9
Total	37.7	46.7	9.0

Table 18. School ADC Percentages for the Samples[a]

I. Original Sample:	
0 - 4 %	10 Schools
5 - 8 %	4 Schools
9 - 12 %	0 Schools
13 - 16 %	1 School
17 - 20 %	2 Schools
21 - 30 %	2 Schools
40 - 50 %	1 School
II. Final Selected Sample:	
TWHR	
0 - 4 %	3 Schools
5 - 8 %	2 Schools
TWLR	
0 - 4 %	4 Schools
46 %	1 School

[a] School-system-wide average: 12 %

Table 19. Teacher Scores and Percentiles on Watson-Glaser Test[a]

Teacher	Score	Percentile
b 1	69	10
b 2	73	20
b 3	86	84
b 4	90	95
b 5	80	54
6	83	69
7	77	38
8	declined to complete test	
9	90	95
10	94	98
11	83	69
12	declined to complete test	
13	81	58
14	87	86
15	74	25
b 16	82	63
b 17	91	97
b 18	79	51
b 19	88	89
b 20	73	20

[a] Percentiles based on raw scores of incoming master's candidates in the College of Education of The Ohio State University for five years (n = 530).

[b] Teachers used to identify the student sample for hypotheses testing.

BIBLIOGRAPHY

1. Aschner, Mary Jane. The Language of Teaching. In Language and Concepts in Education (eds. B. O. Smith and R. H. Ennis). Chicago: Rand McNally, 1961.

2. Aylesworth, Thomas G. and Reagan, Gerald M. Teaching for Thinking. Garden City, New York: Doubleday and Company, Inc., 1969.

3. Bahrick, H. P. Incidental learning at five stages of intentional learning. Journal of Experimental Psychology, 1957, 54, 250-261.

4. Baltimore Public Schools. An Early School Admissions Project: Progress Report. Baltimore: 1963-1964.

5. Baumeister, A. A. A comparison of normals and retardates with respect to incidental and intentional learning American Journal of Mental Deficiencies, 1963, 68, 404-408.

6. Bellack, Arne A. The Language of the Classroom. New York: Columbia University Press, 1965.

7. Bereiter, C. E. A beginning language program for disadvantaged children. Paper presented at the American Educational Research Association, Chicago, February, 1966.

8. Biel, W. C., and Force, R. C. Retention of nonsense syllables in intentional and incidental learning. Journal of Experimental Psychology, 1943, 32, 52-63.

9. Blank, M. Cognitive gains in "deprived" children through individual teaching of language for abstract thinking. Paper presented at the meeting of the Society for Research in Child Development, March, 1967.

10. Benser, Frederick G. The Reasoning Ability of Children of the Fourth, Fifth, and Sixth School Grades. New York: Columbia University, 1910.

11. Boyd, William McKendree. Output interference in prose learning. Paper presented at the annual meeting of the American Educational Research Association, 1972.

12. Brazziel, W. F., and Terrell, Mary. An experiment in the development of readiness in a culturally disadvantaged group of first grade children. Journal of Negro Education, 1962, 31, 4-7.

13. Brent, Sander B. and Katz, Evelyn W. A Study of Language Deviations and Cognitive Processes. Detroit: Wayne State University, 1967.

14. Brown, G. H. Factors influencing incidental learning. Journal of Experimental Psychology, 1954, 47, 163-169.

15. Burt, Cyril. The development of reasoning in school children. Journal of Experimental Pedagogy, 1919, 5, 68-77, 121-127.

16. California Test Bureau. Comprehensive Tests of Basic Skills. Monterey, California: California Test Bureau, 1968.

17. Campbell, Donald T. and Stanley, Julian C. Experimental and quasi-experimental designs for research on teaching. In Handbook of Research on Teaching N. L. Gage (ed.). Chicago: Rand McNally, 1963.

18. Dixon, W. J. (ed.). BMD Biomedical Computer Programs. Berkeley: University of California Press, 1968.

19. Ennis, Robert H., Gardiner, William L., Guzzetta, John F., Morrow, Richard G., Paulus, Dieter, H., Ringel, Lucille. A Description of "The Cornell Conditional Reasoning Test, Form X." Ithaca: Cornell University, 1964.

20. Ennis, Robert H. A concept of critical thinking. Harvard Educational Review, 1962, 32, 81-111.

21. Ennis, R. H. and Paulus, D. H. Critical Thinking Readiness in Grades 1-12; Phase I: Deductive Logic in Adolescence. Ithaca: Cornell University, 1965.

22. Exner, Robert M. The Forum: Should mathematical logic be taught formally in mathematics classes? Pro. The Mathematics Teacher, 1971, 64, 388, 394-401.

23. Feldman, Shirley. A preschool enrichment program for disadvantaged children. New Era, 1964, 45, 79-82.

24. Fey, James Taylor. Patterns of Verbal Communications in Mathematics Classes. New York: Teachers College Press, 1970.

25. Gage, N. L. Paradigms for research on teaching. In Handbook of Research on Teaching N. L. Gage (ed.). Chicago: Rand McNally, 1963.

26. Gallagher, James J., Aschner, Mary Jane, and Jenne, William. Productive Thinking of Gifted Children in Classroom Interaction. Washington: NEA, 1967.

27. Glaser, E. An experiment in the development of critical thinking. Psychological Bulletin, 1941, 38, 576-577.

28. Hall, Edward T. The Silent Language. Greenwich, Connecticut: Fawcett Publications, 1963.

29. Hannemann, Charles Edward. The effects of two methods of instruction upon the ability of sixth grade students to make inferences and apply principles. (Unpublished doctoral thesis, Ohio University, 1969).

30. Hayweiser, Lois, Massari, D., and Meyer, W. J. Evaluating behavior change during a six-week pre-kindergarten intervention experience. Paper presented at the annual meeting of the American Educational Research Association, 1967.

31. Hetherington, E. M. and Bante, T. J. Incidental and intentional learning in normal and mentally retarded children. Journal of Comparative Physiological Psychology, 1962, 55, 402-404.

32. Hill, Shirley. A study of logical abilities in children. (Unpublished doctoral thesis, Stanford University, 1961).

33. Hilton, Peter J. The Forum: Should mathematical logic be taught formally in mathematics classes? Con. The Mathematics Teacher, 1971, 64, 389-394.

34. Howell, Edgar N. Recognition of selected inference patterns by secondary school mathematics students (Unpublished doctoral thesis, The University of Wisconsin, 1965).

35. Hunt, J. McV. The psychological basis for using preschool enrichment as an antidote for cultural deprivation. Merrill-Palmer Quarterly, 1964, 10, 209-248.

36. Hunt, K. W. Grammatical Structures Written at Three Grade Levels. Champaign, Illinois: National Council of Teachers of English, 1965.

37. Hyram, G. H. An experiment in developing critical thinking in children. Journal of Experimental Education, 1957, 26, 125-132.

38. Inhelder, B. and Piaget, J. The Growth of Logical Thinking. (A. Parsons and S. Milgram, trans.). New York: Basic Books, 1958.

39. Isaacs, S. Intellectual Growth in Young Children. New York: Harcourt, Brace, 1930.

40. Jahnke, John C. A behavioristic analysis of instruction. In Instruction: Some Contemporary Viewpoints Laurence Siegel (ed.). San Francisco: Chandler Publishing Company, 1967.

41. Jenkins, J. G. Instruction as a factor in "incidental" learning. American Journal of Psychology, 1933, 45, 471-477.

42. Kausler, D. and Trapp, E. Motivation and cue utilization in intentional and incidental learning. Psychological Review, 1960, 67, 373-379

43. Kausler, D., Trapp, E., and Brewer, C. Intentional and incidental learning under high and low emotional drive levels. Journal of Experimental Psychology, 1959, 58, 452-455.

44. Koran, Mary Lou and Koran, John J., Jr. Differential response to question pacing in learning from prose. Paper presented at the annual meeting of the American Educational Research Association, 1972.

45. Lucas, A. M. Multiple marking of a matriculation biology essay question. The British Journal of Educational Psychology, 1971, 41, 78-84.

46. McGeoch, John A. The Psychology of Human Learning. New York: Longmans Green, 1952.

47. Marx, Melvin H. (ed.). Learning and Processes. Toronto: The MacMillan Company, 1970.

48. Measel, Wesley W. The relationship between teacher influence and levels of thinking of secondary grade teachers and pupils. (Unpublished doctoral thesis, The University of Michigan, 1967).

49. Miller, E. H. A study of the difficulty levels of selected types of fallacies in reasoning and their relationships to the factors of sex, grade level, mental age, and scholastic standing. Journal of Educational Research, 1955, 49, 123-129.

50. O'Brien, Thomas C. and Shapiro, Bernard J. The development of logical thinking in children. Paper presented at the annual meeting of the American Educational Research Association, Chicago, February, 1968.

51. Osborne, Alan R. and Crosswhite, F. Joseph. Forces and issues related to curriculum and instruction, 7-12. In A History of Mathematics Education in the United States and Canada: Twenty-second Yearbook Phillip S. Jones (ed.). Washington, D. C.: National Council of Teachers of Mathematics, 1970.

52. Phye, Gary Dean. Incidental verbal learning, a developmental study. (Unpublished doctoral thesis, University of Missouri--Columbia, 1970).

53. Piaget, Jean. Logic and Psychology. New York: Basic Books, 1957.

54. Postman, L. and Senders, V. L. Incidental learning and generality of set. Journal of Experimental Psychology, 1946, 36, 153-165.

55. Quellmalz, Edys S. Effects of response requirement type, placement, and category upon attention patterns influencing prose learning. Paper presented at the annual meeting of the American Educational Research Association, 1972.

56. Roberge, James J. Negation in the major premise as a factor in children's deductive reasoning. School Science and Mathematics.

57. Roy, Gregory Raymond. The effect of the study of mathematical logic on student performance in proving theorems by mathematical induction. (Unpublished doctoral thesis, State University of New York at Buffalo, 1970).

58. Sapir, Edward. Language: An Introduction to the Study of Speech. New York: Harcourt, Brace, 1949.

59. Schooley, M. and Hartmann, G. W. The role of insight in the reasoning of logical relations. American Journal of Psychology, 1937, 49, 287-292.

60. Shellow, S. M. Individual differences in incidental memory. Arch. Psychology, 1923, 10, 64.

61. Smith, B. Othanel and Meux, Milton. A Study of the Logic of Teaching. Urbana: University of Illinois, 1962.

62. Smith, B. Othanel. The need for logic in methods courses. Theory Into Practice, 1964, 3, 5-8.

63. Suppes, P. The Development of Mathematical Concepts in Children. Stanford: Stanford University, 1964.

64. Tolman, E. C. There is more than one kind of learning. Psychological Review, 1949, 56, 145-155.

65. Walberg, Herbert, Sorenson, Juanita, and Fischback, Thomas. Ecological correlates of ambience in the learning environment. American Educational Research Journal, 1972, 9, 139-148.

66. Watson, Goodwin and Glaser, Edward M. Watson-Glaser Critical Thinking Appraisal. Chicago: World Book Company, 1952.

67. White, E. E. A study of the possibility of improving habits of thought in school children by training in logic. The British Journal of Educational Psychology, 1936, 6, 267-273.

68. Whorf, Benjamin Lee. Science and linguistics. In Readings in Applied English Linguistics Harold B. Allen (ed.). New York: Appleton-Century-Crofts, 1964.

69. Williams, Billy Richard. Critical thinking ability as affected by a unit on symbolic logic. (Unpublished doctoral thesis, Arizona State University, 1971).

70. Winch, W. H. Children's reasonings: experimental studies of reasoning in school children. The Journal of Experimental Pedagogy, 1921, 6, 121-141, 199-212, 275-287.

71. Woodcock, Louise P. Life and Ways of the Two-Year-Old. New York: E. P. Dutton, 1941.

72. Wright, E. Muriel J. and Proctor, Virginia H. Systematic Observation of Verbal Interaction as a Method of Comparing Mathematics Lessons. St. Louis: Washington University, 1961.